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THE PENNSYLVANIA RAILWAY FRANCHISE for a tunnel under the North River and city, approved by the Rapid Transit Commission, has been rejected by the New York Board of Aldermen. The reasons given for this action are—That it is a grant in perpetuity; that the railway company may use the tunnel for carrying freight through the city to a new and remote shipping point; and that no provision is made for the employment of labor at union rates in its construction. In the coming conference between the city, commission and railway, the answers to these objections will be that—As the city has the right to adjust the rate of compensation to be paid to the city at the end of each 25 years, the grant is not in perpetuity; the purpose of the tunnel is to carry passengers only and there is no danger of transferring the commerce of New York; and finally, the railway is a foreign corporation, and a provision in the contract regulating labor would be unconstitutional. It is believed that these difficulties can be adjusted. This tunnel is to cost from $40,000,000 to $50,000,000, and under the terms offered the city would secure over $2,500,000 for the first 25 years.

THE BROOKLYN EXTENSION of the New York Rapid Transit subway will be built by the Belmont-McDonald interest, and the Rapid Transit Commission accepted their bid of $2,000,000 for this work on July 24. The conditional bid of the same company—of $3,000,000, to build the tunnel under the East River and a subway under Broadway, from Union Square to 42d St., was not considered by the Commission. The reason given for this course was that the Broadway tunnel was not up for consideration at the present time. The sum of $1,000,000 must be added to the river tunnel bid, as that amount is allowed by the Commission for real estate and terminals.

SHORT CIRCUITS ON THE ELECTRIC ELEVATED lines in New York city have been quite frequent since the inauguration of the system less than six months ago. One or two of the more serious accidents caused by them have already been noted in these columns. During the past month several such accidents occurred. On July 9, three men were on a platform suspended beneath the roadway of the elevated structure on 42d St., near Third Ave., at work repairing the track. An unexplained short circuit enveloped them with a sheet of flame, and burned them so severely that they were taken to the hospital. A second similar burst of flame shortly after severely burned an electrician of the company, who was at work on the platform repairing the damage caused by the first short circuit.——On July 15 a surface car on the 23d St. line, in New York city, was about to come to a stop under the structure of the Second Ave. elevated line at Second Ave., when an elevated train passed overhead. It is supposed that a short circuit occurred on one of the cars of the train; at any rate, a great flash of flame shot downward, around the surface car. The car, an open one, was crowded with passengers, and the flames, together with the attendant panic, resulted in injuries to half a dozen people, some of them burned, others only bruised.

RAILWAY RATES ON THE TRANS-SIBERIAN RAILway are given as follows by U. S. Consul Henry B. Miller, of Ninchwang, Manchuria: Railway fares from Nagasaki, Japan, to Port Arthur are—$15.45, $10.30 and $5.15 for the three classes; from Port Arthur to St. Petersburg the railway fares are—$62.57, $46.81 and $30.36 respectively. To these fares must be added sleeping-cars rates between Irkutsk and Moscow or St. Petersburg; these are, to Moscow, $9.73 and $5.84 for first and second class; and to St. Petersburg, $11.00 or $7.37 respectively. Only 36 lbs. of luggage, in addition to hand valises, will be carried free; for all excess weight the charge is $2.06 for each 10 lbs. from the Pacific to St. Petersburg. The cost of a first-class ticket from Japan to London varies from $118.45 to $144.50, according to route, and the trip can be made in 25 days. All travelers should be provided with passports properly issued by a Russian consul; they should carry blankets and pillows; and they may travel long distances without meeting any one who can speak any language but Russian. Meals cost from 20.6 cts. to $1.03. There are only two trains per week between Irkutsk and St. Petersburg, but these are provided with all modern comforts, and make the trip in eight days. From Irkutsk to Port Arthur the journey is rough and only mixed passenger and freight trains are run.

THE COMPLETION OF THE JEROME PARK RESERvoir, New York City, has been set for Aug. 1, 1904, in a proposed agreement between the Aqueduct Commission and McDonald & Onderdonk, contractors for the work. This agreement, which must be approved by the Board of Estimate and Apportionment, is accompanied by a provision for a change from a 10-hour to an 8-hour day, and an increase of some $464,000 in the contract price for the reservoir. The contract was made in 1895, before the 8-hour day act was passed by the legislature.

FORESTRY IN THE DRAINAGE AREA of the water supply of Newark, N. J., is under consideration by the Street and Water Commissioners of that city. Prof. F. R. Meier, Forester of the New Jersey Geological Survey, has been consulted. Mr. Morris R. Sherrerd, M. Am. Soc. C. E., is Engineer and Superintendent of the Department of Water.

BIDS FOR A SLOW-SAND FILTRATION PLANT at Washington, D. C., will be received on Aug. 12, as outlined in our advertising columns. Lieut.-Col. A. M. Miller, M. Am. Soc. C. E., is engineer in charge.

A RESERVOIR FAILURE occurred July 6, on the Hope Ranch of the Pacific Improvement Co., near Santa Barbara, Cal. The reservoir had a capacity of 2,000,000 gallons, and had been completed but a short time. It is said that a gap of 25 ft. was made in one wall and that the reservoir was nearly full at the time. Mr. J. K. Harrington was engineer in charge.

THE ASSOCIATION OF MANAGERS OF SEWAGE disposal works held a meeting in London a few weeks ago. Dr. S. N. Rideal presented a paper in which he criticised the recent progress report of the Royal Commission on Sewage Disposal for omitting from its classification upward filtration with nitrifying trays and closed septic tanks followed by continuous filtration. The latter he considered the nearest approach to nature and one that would give good results.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pennsylvania Lines West of Pittsburg, near Xenia, O., on July 25. An eastbound limited express train from St. Louis to New York was going at a very high speed when it collided with a coal car which had broken loose from a line of cars on a siding and was running wild down grade in the opposite direction to the passenger train. The latter was completely wrecked. Four men of the train crew and three passengers were killed and many others injured. The reservoirs of compressed gas under the cars exploded soon after the collision. The entire train was burned, and the mail it carried was destroyed.——On July 24 a washout on the Sonora Ry., near Llano, Mexico, ditched a passenger train. Five persons are said to have been killed.——At least three fatal railway accidents besides those mentioned occurred during the past week, each claiming one victim. One of them was the explosion of the boiler of a locomotive on the Baltimore & Ohio R. R., near Ravenna, O., on July 23.

A FATAL TROLLEY CAR COLLISION occurred on the line of the Fair Haven & Westville St. Ry. Co., near New Haven, Conn., on July 26. Two opposing cars on a single-track line crashed together on a grade, due to the motorman of one car leaving his siding before the block was all clear. Both cars were large and heavy interurban cars, and they partially telescoped on colliding; one person was killed and several were seriously injured.

AN ELEVATED RAILWAY ACCIDENT occurred on the lines of the Brooklyn Rapid Transit Co., New York City, on July 28. Two trains on different lines were approaching a Y-junction point near the east end of the Brooklyn Bridge, one of them having a clear track. The motorman of the other train kept on, however, in full view of the signal set against him, and his train struck the side of the other, throwing several cars off the track. Fortunately all the cars remained on the elevated structure. Two persons were caught between the car platforms and were probably fatally injured; a large number of others were hurt more or less seriously.

THREE STREET-REFUGE ISLES are to be built on Broadway, New York, as soon as the appropriation is available. These isles will be placed at points of heavy traffic—at 14th, 23d and 34th St. crossings of Broadway. The plans call for an oval area in the middle of the street, 60 ft. long and 35 ft. wide, with four ornamental lamp posts and a central stairway leading to an underground public comfort station. One design calls for subways connecting the isles with the pavement. No estimate of cost is given. These mid-street refuges have been used for years in London and in Continental cities.

MACADAM ROADS BUILT with the proceeds of liquor licenses are a feature of Jackson Co., Mo. According to the Kansas City "World" some 230 miles of such roads, centering in Kansas City, and costing about $1,250,000, have been built. Two-thirds of the license money is expended for road and bridge construction, under the direction of the county court. A direct tax of 15 cts. per $100 valuation is also assessed for road purposes, and from these two funds, it appears, all the roads in the county are constructed and maintained.

A LAKE JOLIET POWER PLANT is proposed by a Chicago syndicate. As published in the Chicago press, this syndicate proposes to acquire the fall of 14 ft. at Jackson St., Joliet, which was developed to the extent of 7,000 HP. by the Economy Light & Power Co. The new dam would be located below this point—or a mile south of the city—where 23-ft. fall could be secured, and 12,000 HP. at once developed. The syndicate is said to have acquired much of the desired land, and the plans prepared contemplate the expenditure of at least $1,000,000. This scheme would seriously interfere with the utilization of this power by the city of Chicago, for use in operating the lighting and pumping plants. Chief Engineer Randolph, of the Sanitary Board, says in an interview in the "Record-Herald," that the Sanitary Board controls property which he believes would be essential to the success of the proposed syndicate scheme.

A NEW POWER PLANT on the Susquehanna River, near Conowingo Falls, is proposed by a syndicate interested in developing power on the same river at Peach Bottom. The estimated cost is $12,000,000 for 150,000 HP. Mr. S. D. Warfield, President of the Continental Trust Co., of Baltimore, is named as the head of the syndicate, and it is proposed to distribute this power to Baltimore, Wilmington and smaller towns.

A COMPETITIVE EXAMINATION will be held at Pittsburg and Chicago, on Aug. 19-20, 1902, for the purpose of establishing a register of men eligible for the position of architectural and structural steel draftsmen at the Navy Department and at the various navy yards. The pay will be $5.04, $4.72 and $4.48 per day, and full instructions as to the scope of the examination can be obtained by addressing the Secretary of the Navy, before Aug. 15.

THE NEW WAVE DETECTOR invented by Mr. G. Marconi as a substitute for the coherer in wireless telegraphy was described by him recently in a lecture before the Royal Institution in London. The instrument makes use of the influence of a rapidly oscillating current on the magnetic condition of a magnet in its neighborhood. A small magnet core is surrounded by two coils, the one, of fine wire, being connected with the telephone receiver; the other, of coarser wire, being connected with the vertical receiving wire of the station. The magnet core has its magnetism constantly varied by a permanent magnet moved or rotated near it. When waves reach the receiving wire and pass through the primary of the instrument, they affect the hysteretic lag of the core behind the induction of the permanent magnet, and thus give rise to a current wave in the secondary of the instrument. This current wave is heard as a sound in the attached telephone receiver. In the final form of the instrument as devised by Mr. Marconi, the magnet core is made up of iron wire, which is wound in several turns over two grooved wheels set a short distance apart. This wire "band" is moved rapidly by rotating one of the grooved wheels. The permanent inducing magnet is fixed over the upper rim of the wire band, and the motion of the latter produces the variation in magnetic condition along the wire of the band. The primary and secondary coils encircle the lower rim of the band; the oscillations in the primary, by altering the amount of lag in the iron wire, cause the magnetization to move along the wire, momentarily, and thus produce a current wave in the secondary. Mr. Marconi has used this wave detector for continuous receiving at the rate of 30 words per minute. He hopes soon to operate it with a recorder, by which means he thinks a speed of as much as 100 words per minute might be attained.

DISTURBANCE OF ROADBED AND BRIDGES BY FROST ON THE TRANS-SIBERIAN RAILWAY.

In a recent issue of the "Organ für die Fortschritte des Eisenbahnwesens," Mr. L. von Lubimoff, Chief Engineer of the Trans-Siberian Railway, describes an interesting phenomenon of frost action which has been observed on the line of that railway in Siberia. This phenomenon, the distortion of wooden trestle bridges by the action of frost, is closely connected with the extensive frost disturbances of the roadbed in general which are encountered in both European and Asiatic Russia, but while the latter effect has been known for some time, the action on the bridge structures has been noted and studied only during the last few years.

The disturbance of the roadbed by frost is a very serious matter, states Mr. von Lubimoff; on

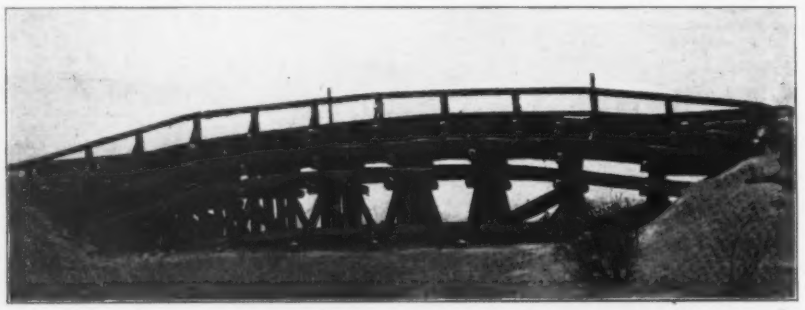

FIG. 1. UPHEAVAL OF SMALL WOODEN BRIDGE ON TRANS-SIBERIAN RAILWAY, SHOWING METHOD OF REPAIR BY BANKING THE APPROACHES.

95% of all Russian railway lines it constitutes one of the most important problems of maintenance of way. The disturbance occurs mainly in low-lying, wet ground; the soil in such places is generally found to be clay overlying or with intervening layers of water bearing sand or gravel. The action in prolonged cold weather seems to be about as follows: The earth gradually freezes downward, and as the moister strata are reached the contained water causes them to freeze in thin sheets or laminations. As the frozen layer increases in thickness, it tends to separate from the strata below and to form bumps or hillocks. A succeeding rise of temperature produces an open and porous structure in the frozen layer, and any water entering from either above or below fills the interstices; when the temperature again falls this water freezes and by its expansion further raises the swelling.

In time this process produces noticeable roughness of the roadbed, which may be so extensive as to make traffic at any considerable speed positively dangerous. Mere resurfacing (for instance, as shown in Fig. 1, by banking-up the approach fills) is only a temporary expedient. The only effective means to deal with portions of the railway line that are thus affected has been found to be (1) to drain the surrounding soil thoroughly by deep drainage ditches, so that the ground water level in the neighborhood of the roadbed is lowered well below any possibility of frost extending down to it, or (2) to increase the depth of filling sufficiently to protect the natural ground below it from the action of frost. The filling must be of open texture and well drained, so that it will not itself give trouble in the same way. Both methods of protection are where possible used simultaneously.

The distortion of bridges is a more difficult matter to cope with, though of course the aggregate of damage and interference with traffic is very much less. The action is clearly shown in the accompanying views, which require but little explanation. It may be stated that the piles are in each case driven well down into the subsoil below frost level, but the rising of the surface layers, as explained above, lifts the piles up with it by friction.

The bridge shown in Fig. 1 is about 55 ft. in span. The nature of the creek bed is as brought out above, marsh soil on clay, to a total depth of about 12 to 15 ft., overlying gravel. When the ground is frozen, the water finds its way largely through the gravel stratum. This bridge was built in 1896. In the following year it showed a rise at the center of 10 ins.; in another year this increased to 23 ins., decreasing in the following summer to 14 ins. In the winter of 1900-01 the total rise amounted to as much as 45 ins., and finally, in the summer of 1901, the bridge was replaced by a steel span on masonry piers. The view in Fig. 2 shows another and somewhat longer bridge, which shows the same upheaving action of the frost. This bridge has also been replaced recently by a steel structure.

THE SELECTION AND INSTALLATION OF HYDRAULIC ELEVATORS.

By Henry D. James,* M. E.

The increasing value of real estate in our large cities has resulted in the erection of high buildings. These in turn have been made possible by the development of the elevator. Upon its proper design and installation depends, in a great measure, the desirability of the upper floors.

In connection with the elevator, the first question that arises in designing a large office building is how many elevators should be provided and how large should the cars be made. The size is determined partly by the design of the building, but the cars are generally made between 5 and 6 ft. square. Larger cars are unwieldy and inefficient for the average load; small ones will not take care of the passengers during the rush hours.

The number of cars is a difficult question to solve, and must be governed much by experience. In the neighborhood of a stock exchange the requirements are very severe, and a liberal number of elevators should be provided. Up town a smaller number will give good service. Average conditions require about one elevator to every 25,000 sq. ft. of total floor area in the building, but this figure must not be taken as applying to all conditions; it is only to give a rough idea as a basis on which to start.

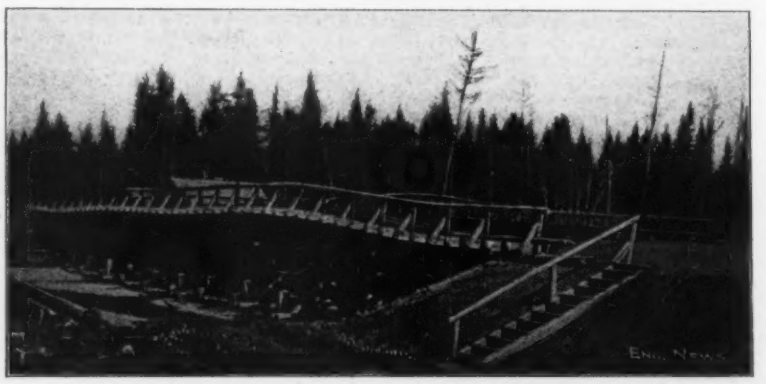

FIG. 2. LONG TRESTLE BRIDGE DISTORTED BY FROST.

The speed of the elevator depends upon the height of the building. For a ten or twelve-story building 300 ft. per minute is ample. This rise will not justify the use of express elevators, and each elevator will have to serve all floors, averaging a stop at every two or three landings during rush hours. Increased speed would make very little difference in the time taken to make a round trip and would be less comfortable to the passengers. For buildings of 18 or 20 stories speeds of 500 or 600 ft. per minute are used. Here part of the plant can be used for express service and advantage can be taken of the higher speed.

It is a disadvantage to run a car faster than the conditions warrant. It is disagreeable to many passengers and increases the strain on the machinery. It also requires larger pipes, tanks and pumps, often increasing the cost where slower running elevators would give just as good service. One of the large 20-story buildings in the lower part of New York city had elevators designed for a speed of 600 ft. per minute. It was deemed advantageous to reduce the speed to about 400 ft. per minute, as that was found sufficient to maintain the service, and the lower speed was more satisfactory to the tenants of the building.

The proper load for a passenger car is 75 lbs. per sq. foot of platform area. This represents about the capacity of the car when well filled, and the careful engineer must design his elevator to take care of this load, even if it is not specified, as there is nothing to prevent people from crowding the car to its extreme capacity. The cylinder should be made large enough to lift this load, as otherwise the elevator runner will frequently have to ask part of his passengers to step out, so that the car may rise. Generally this maximum load is specified at a moderate speed, and from one-half to two-thirds of this load can be lifted at the maximum speed. Thus, a car 5 ft. 6 ins. x 10 ft., with 200 ft. rise, should have a maximum load of 2,500 lbs. and an average load of 1,500 lbs., with a speed of, say, 500 ft. per minute.

The pumps for hydraulic elevators are nearly always driven by steam, although in some cases there is installed an auxiliary pump run by an electric motor taking current from the street mains. This will operate one or two cars at night or on holidays, when it is not economical to keep the steam boilers in commission. The steam pressure should be at least 90 to 100 lbs., so that compound pumps can be used and a water pressure of 125 to 150 lbs. maintained. The higher the water pressure selected, the smaller the pipes, tanks and cylinders, and the less the cost. As most standard apparatus is designed for a working pressure of 150 lbs. per sq. in., such pressure involves no additional expense. After 150 lbs. is passed, the apparatus becomes special, and therefore more expensive. From this point the pressure generally jumps to 600 or 700 lbs., and regular high-pressure machines are used with accumulators. This high-pressure work is often economical where the elevators are scattered over a large area and the piping system becomes very expensive; but it requires more skilful supervision than the 150-lb. pressure system.

Each office building generally has one elevator specially designed to lift safes at a slow speed. The parts are strengthened so as to stand about 300 lbs. pressure and a small pump is connected to the cylinder by an additional piping system of about 2 ins. diameter, with the necessary valves in each system. No one should ride in the car when heavy safes are carried.

The supports for the sheaves and guides should always be of steel. The guides are generally made of "tee iron," and should be at least 3 ins.

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deep by 4½ ins. or 5-in. flange. They should be doweled together at the joints and supported by steel brackets at least every 8 or 10 ft. If this is not possible, they should be backed up by channel or angle iron. In case of excessive speed, the safety device under the car grips these guides in stopping the car. Under these conditions a very heavy load is thrown on them, and they should be strong enough to withstand it.

In vertical machines it is best to place the cylinder as close to the car as possible, generally directly behind the shaft. Horizontal machines are usually placed close by the shaft in the basement or sub-basement. These latter machines are often stacked one above the other in order to save room or space. The vertical cylinders can be made longer than the horizontal ones, and thus have a greater stroke. This enables a lower gear to be used and gives a more efficient machine, as the engine and journal frictions increase directly as the gear. The length of the vertical cylinder is limited principally by the fact that a perfect vacuum will not maintain a column of water over 34 ft. high. When the cylinder exceeds about 30 ft. in length it is necessary to siphon the exhaust; it is therefore very seldom that cylinders are made over 40 ft. long, while generally their length does not exceed 30 ft. Sometimes on low rises, where a high speed is specified, the machine has to have a high gear in order to keep down the piston speed.

All horizontal machines should have an independent counterweight connected directly to the car, and the same is true of all vertical machines of over 4 to 1 gear. With the vertical cylinder it is possible to place weights in the traveling sheaves strap, which, together with the other moving parts, help to counterbalance the car. This counterbalancing is inversely proportional to the gear. Thus, with a 4 to 1 gear, in order to counterbalance 2,000 lbs. of car weight, 8,000 lbs. would have to be hung from the traveling sheaves. This method of counterbalancing is very convenient, as it does not require any additional guides or sheaves, but with large cars and high gears it is best to use an independent counterweight in addition. The accompanying cuts will illustrate these different methods of counterbalancing.

Where the vertical cylinders are placed next to the cars with no wall intervening, the traveling sheaves should be guided; for, should the ropes break when the sheaves are at a distance from the cylinder, the weight would bend the rods, and there is danger of the sheaves falling over on the car.

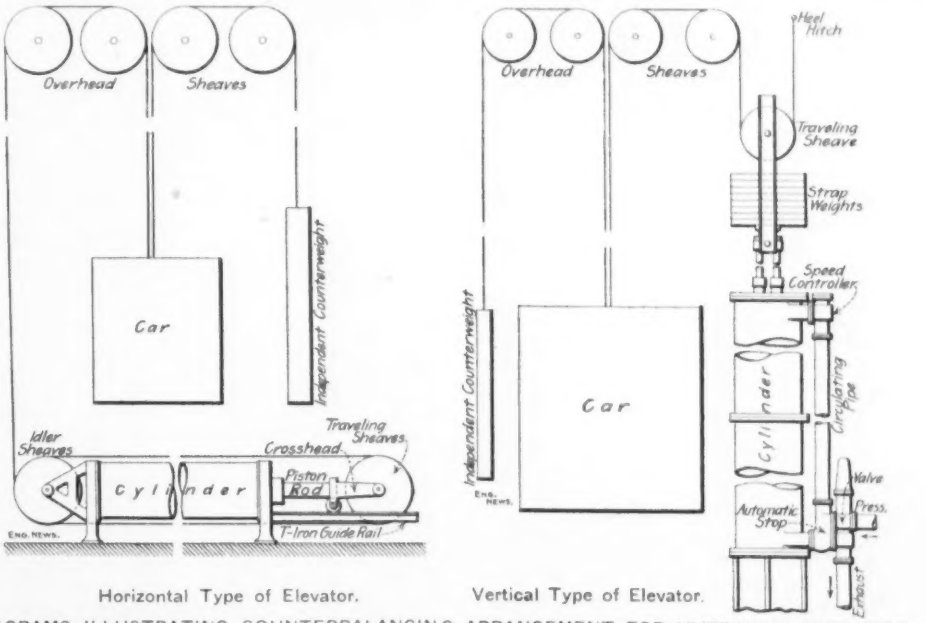
The length over all of a horizontal machine is about twice the stroke plus 10 ft. Sufficient clearance should be left around the machine to attend to it properly.

Each type of machine has its advantages. The vertical cylinder has a lower gear, and is therefore easier to control and has less friction. The cylinder can be placed back of the car, leaving only the pumping plant in the basement. The car can be counterbalanced by means of additional weights to the moving parts. The horizontal cylinder has more friction, but it can be placed down in the basement, leaving the hatchway perfectly clear. A partition can shut the machine off entirely from the hatchway, thus cutting off any noise from the rest of the building. These advantages can be obtained with the vertical type by placing the cylinders in a separate enclosed hatchway. The conditions controlling the design of the building determine in part which kind of machine to use. Either type should have a chain connected from the bottom of the car to either the independent counterweight or the center of the hatchway, to compensate for the weight of rope that shifts from the car to the machine, and vice versa. In a few cases the chain counterbalance has been omitted and a column of water used to compensate for this difference, the machine exhausting against an increasing back pressure (vertical circulating type machines only). This method requires larger machines and additional piping; it is not be recommended.

The car design should be selected with a view to making it as light as possible. The machine has to lift the load, plus the unbalanced weight of the car. The unbalanced weight must be sufficient to overcome all frictions and cause the car to descend at contract speed with only an operator in it. The greater the weight of the car, the more friction and the more unbalanced weight the cylinder must lift. The modern office building car, complete with safeties and operating mechanism, often weighs between 3,000 and 4,000 lbs., requiring 500 lbs. or more to be left unbalanced.

All cars running over 200 or 300 ft. per minute should be controlled by a lever placed in the car. This lever generally has a maximum throw of 25 ins. or 12½ ins., each side of the center. It controls the main valve by means of a pilot valve. There are a number of different lever and wheel devices which take up more or less room and operate with varying degrees of satisfaction, but the above is the most common in this country.

In addition to the regular safety placed under the car, the hydraulic machine should be equipped with an automatic stop at each limit of its travel. This consists of a valve connected to the traveling sheave strap by means of a rope and proper gearing. This valve should be positive in its operation and not easily put out of order or tampered with. Cars are often, in addition, equipped with an emergency lever. This enables the operator to grip the guides and stop his car, should the regular safety device fail to operate. On all machines having a speed above 350 ft. per minute, there should be placed in the feed pipe a speed controller. This is a valve that closes automatically when the velocity of water through it exceeds a certain predetermined maximum.



Horizontal Type of Elevator. Vertical Type of Elevator.

DIAGRAMS ILLUSTRATING COUNTERBALANCING ARRANGEMENT FOR HYDRAULIC ELEVATOR CARS.

The "air cushion" is another safety device often employed in tall buildings. It is intended to be used only as a last resort, and is not effective unless the car velocity is quite high. The tests that have been made, however, seem to indicate its ability to save life in case of a free fall of the car. The use of this air cushion should never be considered a substitute for a thoroughly effective car safety, or even as an excuse for not using the best safety obtainable.

The car safety should be able to stop at least one-third to one-half more than the total weight of the car plus the full load. The stop must be quick and effective, but not too sudden. There are several of these devices which are reliable and yet do not endanger the passengers by their abrupt action. Where the load (except for safe lifting purposes) exceeds 3,500 to 4,000 lbs., better results with the safeties can be obtained with wooden guides. If a heavy wooden post is undesirable, steel angles or channels can be used.

There should never be less than four lifting ropes for a passenger car connected to a hydraulic machine, and these should have a factor of safety of ten. Wrought-iron rope with a hemp center is used. The danger of using steel rope, with its greater tensile strength, is that you have no positive assurance that the repair men will always use steel rope when they renew them. The iron rope is also more pliable.

The cast iron in the cylinder and valves should not be strained over 1,800 to 2,000 lbs. per sq. in. under the specified pump pressure, as the sudden stopping of cars greatly increase this pressure and relief valves do not always have time to work. There is also danger of such valves sticking.

In designing the direct plunger type of elevator for high rises, special attention should be given to the method of fastening the plunger as a whole to the car and of the different sections of the plunger together. One reliable method is to run a steel rod through the entire length of the plunger from the car platform to the bottom end and securely fasten it there. Contrary to the popular supposition, the plunger, during the upper part of the car travel, is not in compression, but in tension. The difference in weight of the plunger in and out of water, together with the difference in head, must be compensated for by chain or rope counterbalance, which increases the counterweight as the car rises.

The pumping plant for elevator service receives often little or no attention from the designing engineer; yet its importance is second only to that of the elevator machines themselves. The size of this plant is determined by the number of elevators and the minimum time of one round trip allowed for each elevator; this latter is generally called the "schedule" of the elevator. A 2½-minute schedule would be ample for an elevator of 250 ft. rise and 500 ft. speed. Proper allowance should be made for the time required to load and unload passengers. In a high building it is assumed that part of the machines will be run as express elevators.

Hydraulic elevator machines are always single acting; that is to say, they only take water going one way; in the opposite direction they either circulate the water (vertical type) or discharge it. To the latter class belong some vertical and all horizontal machines. All of these elevators consume the same quantity of water, whether they make the complete trip fully loaded or empty. For this reason a double-pressure system has been used in a few places, and seems to give good results. This system requires a double system of pipes and tanks; it therefore takes up more room and costs more to install, but, on the other hand, it saves in the coal bill.

In the single-pressure system the best arrangement of pumps is generally to have three, two of which together are large enough to supply all the water needed to maintain the schedule and an additional 10% to allow for leakage, slip of the pumps, etc., while the third pump is held in reserve. When two pumps only are used, each must be large enough to maintain the schedule, thus increasing the first cost, but giving a little better

efficiency if the elevators are run at equal intervals by the starter, or, in other words, if the consumption of water is kept about uniform, so that the pump is run continuously. This, however, is seldom the case in practice.

Since the pumps are started automatically by a pressure regulator, when three pumps are used one is adjusted to start at a little higher pressure than the other, so that the first pump is kept running under a good load most of the time and the other one is "cut in" as it is needed. Under most conditions this arrangement gives a better all-day efficiency than when one pump is made to carry the entire load.

As the water is consumed the pressure drops and the automatic device starts the pump, but

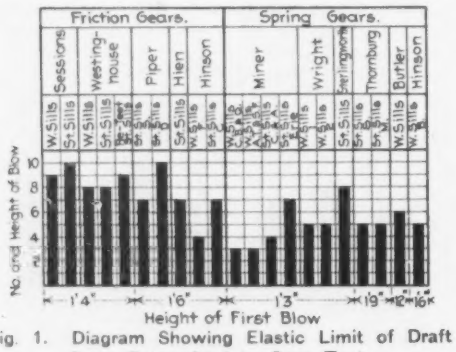


Fig. 1. Diagram Showing Elastic Limit of Draft Gears Determined by Drop Test.

while the pump is getting up speed the pressure continues to drop, so that at first the pump tends to "race" and later on to run quite slowly. For this reason, and also on account of the hard service required from a pump for elevator work, it should be run very slowly, i. e., not over 50 strokes per minute for a 12-in. stroke duplex pump and other sizes proportionately. This is only a little over half the rating given by most pump manufacturers, and they often insist that a small pump will do the work. Experience has shown that at a higher average speed the pumps hammer quite badly at times and the parts become loose. It is always better to have your pumping plant of liberal capacity, so that at times of unusual crowding the elevators can be run on a quicker schedule for a short time without injury.

Where the steam pressure is sufficient, compound pumps should be used, as they consume about one-third less steam than the simple pumps. If the plant is a large one, still better results can be obtained from triple-expansion pumps, but the steam pressure in this case should be quite high. In a few instances the three-cylinder pumping engine with crank and flywheel has been used. This gives the best efficiency, but costs much more than the triple-expansion pumps and requires careful supervision.

The velocity of water through the pipes should not exceed 12 to 14 ft. per second. Each machine should have separate supply and discharge pipes leading from the tanks and be provided with the necessary valves to cut it off entirely from the rest of the system without interfering in any way with the other elevators. All machines should have suitable drip connections, not only to draw off the water when desirable, but also to free the cylinder entirely of air when it is being filled with water. The pressure tank should be large enough to maintain the pressure fairly steady and not to let it drop below a predetermined minimum when the maximum number of elevators are in operation. About one-third of the tank is filled with air, the volume of air being determined from the amount of water supplied by the tank and the minimum pressure that will give the required duty. Where the conditions permit, the tank should be placed at the top of the building and connected by a standpipe with a small auxiliary pressure tank in the basement. The head of water helps to keep the pressure constant and enables a much smaller tank to be used. It also saves space in the basement, which is generally crowded. Most large office buildings have their tanks arranged in this manner. Where the plant is a large one, it is often necessary to split the tank up into two or more units and use two standpipes. Whenever this is done the tanks should be connected by equalizing pipes. The discharge tank or tanks should be large enough to hold the total capacity of all the pressure tanks. The best arrangement is where the pumps, tanks and machines are all close together. Should any of the machines be located at a distance from the tanks, they should be provided with small auxiliary tanks large enough to provide for at least one complete trip of each elevator. Every pressure tank should be provided with a relief valve and sewerage connection, and also with a vacuum air valve to prevent it from collapsing should all the water be suddenly withdrawn. This vacuum valve should never be omitted from tanks at the top of the building, especially. The discharge tank is generally of rectangular section, open on top and provided with a cover. A small air pump should be installed to supply the air lost from the pressure tank by leakage and absorption.

The signaling to the car from the different floors can be done by means of the ordinary annunciator where the building is small and the number of elevators comparatively few. For large installations, the flash signals give by far the best results. With this system but one up and one down button is used at each landing. This signals the first car approaching in the direction desired and also indicates its location, thus saving a great deal of time. If this latter system is used, it is not necessary to have either the "mechanical dial" or "fluid" indicator to show the location of the different cars, except on the main floor, for the information of the "starter." At this floor the "flash" signal should be omitted.

This discussion has had in view primarily the equipment of a modern office building, but the same principles apply to all hydraulic installations. Large hotels require nearly as elaborate a plant as office buildings, but the speed should be less, say not over 300 ft. per minute for the tallest, except in special cases. The pumping plant should be designed to provide economically for the varying demands made upon the elevators during the day and night. Particular attention should be given to suppressing all noise. A freight compartment should never be attached under the passenger car. It is not only unsightly, but a source of danger and reduced efficiency. Either a freight elevator should be installed or rubber-tired trucks provided to handle trunks, etc.

Large department stores should also have hydraulic elevators run at moderate speeds. No form of signaling device seems effective for shoppers. Generally the elevators are stopped at every floor and are apt to be crowded, so that a slow schedule is ample. Where a building requires only two or three elevators of moderate size, the electric machine is generally preferred, but the choice depends largely upon the kind of power available.

The facts presented in this paper are not claimed to be novel or original, but are set forth in the hope that they may be of value to those who have elevators to install.

TESTS OF DRAFT GEAR FOR RAILWAY CARS.*

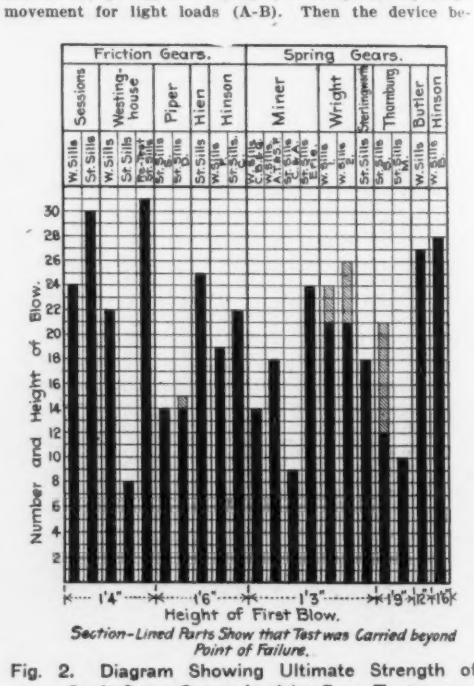
At the annual convention of 1900 a committee of the association was appointed to report upon the requirements of modern draft gear, including spring capacity, size and strength of parts, etc. This committee made a preliminary report at the convention of 1901, in which it proposed that a series of tests be authorized. This authority was granted and the committee undertook a series of drop and tensile tests. Draft gears for these tests were submitted by the makers of such apparatus. The drop tests were made on the drop testing machine of the Pennsylvania R. R. at Altoona, Pa., and the tensile tests were made at the testing laboratory of Purdue University, using a 300,000-lb. testing machine. The report of the committee gave the results of the two series of tests in detail.

DROP TESTS.—The drop tests were made to show the elastic limit, ultimate strength and the height of rebound of the hammers. The testing machine had a hammer weighing 1,640 lbs. and having a maximum fall of 40 ft. In conducting the tests the first blow was struck with a drop of 1 ft. and the drop of each succeeding blow was increased 1 ft. until the result sought was obtained. Figs. 1, 2 and 3 show diagrammatically the results obtained by the drop tests.

TENSILE AND COMPRESSIVE TESTS.—The tensile and compressive tests were conducted at Purdue University under the direction of Prof. J. K. Hatt and Prof. Wm. Forsyth, who describe the mode of procedure and the results obtained as follows:

ELEMENTS TO BE MEASURED.—The purpose of the tests is to determine: (1) The Working Limit of the Riggings.—To this end, uniformly increasing loads were applied to the riggings and corresponding movements of the yokes with reference to the sills were observed until the riggings became solid, thus giving what is called in the diagrams below the "compression line," that is, the "buffing line." In case of all friction gears, and in case of some spring gears, the load was then released step by step and the corresponding release curve obtained. The knowledge of this compression and release action is the most valuable part of the tests. (2) The Load at Which any Part of the Coupler or Draft Attachments Might Fail.—To this end, after the compression and release curve had been obtained, the loading was resumed just above the point at which the device became solid, and continued until some part of the rigging failed, or the capacity of the testing machine was reached.

DISCUSSION OF WORKING CAPACITY AND POINT OF FAILURE.—(1) Working Capacity.—In case of spring gears, the working capacity is reached when the springs become solid. To determine this point, it was sometimes necessary to run the load slightly beyond the point of closing of the springs, in order to insure complete closing. In case of a theoretically perfect spring without constraint the line of release would follow back along the line of compression. This is not the case in the diagrams below, partly from the fact that the load was run beyond the point of solidity, and partly because of the friction of the parts of the year. Fig. 4a gives a typical diagram of a spring gear. In case of friction gear, the diagram is represented by Fig. 4b. There is usually a free action of the device, giving, as is proper, a comparatively large movement for light loads (A-B). Then the device be-



Section-Lined Parts Show that Test was Carried beyond Point of Failure.

Fig. 2. Diagram Showing Ultimate Strength of Draft Gears Determined by Drop Test.

comes less yielding under the action of the friction surfaces until solid under a high load (B-C¹-C). On release the friction holds the device solid until a low load is reached (C-D), when the springs force the yoke gently back to the free position of the gear (D-E-A). In testing these gears, release was usually made when the gear appeared to be solid. In some cases (as it turned out on resumption of loading) the release was made prematurely, and a second release curve was then observed. The desire was, of course, to obtain the release before failure of any of the parts of the device was developed. The elements of this test of friction gear, which are of value, are: (a) The free movement of the device under light loads, that is, the length A-B before coming to the steep part of the curve; (b) the capacity of the gear before becoming solid, as shown by the load and energy absorbed up to C; (c) the action of the friction in recoil, as shown by the length C-D and by the area (expressed in terms of foot-pounds of

*Abstract of a committee report presented at the annual convention of the Master Car Builders' Association at Saratoga, N. Y., July 18-20, 1902.

TABLE I.—Showing Results of Tension and Compression Tests of Friction Draft Gears.

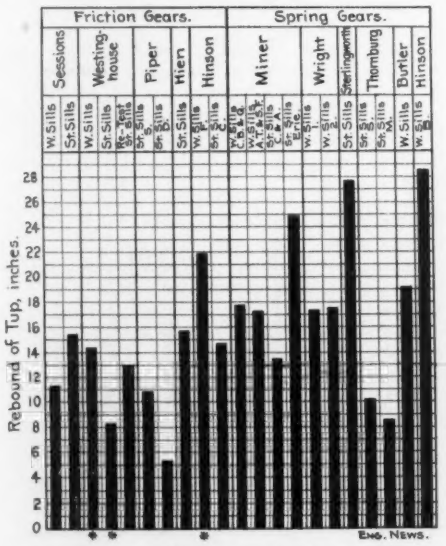
Name of rigging.	Series No.	Movement of yoke at 40,000 lbs. in ins.	Load when solid, in lbs.	Movement when solid, in ins.	Load at failure, in lbs.	Final Set in ins.	Work Total in ft.-lbs.	Work Absorbed by friction-in ft.-lbs.	Absorption in per ct. of total work.
Westinghouse (steel) ...	1—1	0.77	190,000	2.42	At 300,000; no failure..	0.01	18,339	16,695	90
" " ...	1—2	.66	150,000	2.28	At 300,000; no failure..	....	13,879	12,345	89
" (wood) ...	1—3	.89	170,000	2.53	Sill bearing crushing, 250,000	....	16,933	15,200	89
" " ...	1—4	.71	180,000	2.39	At 300,000; no failure...	.4	16,380	15,000	89
Standard (steel)	2—1	.45	100,000	1.9	At 300,000; no failure..	.05	9,000	7,000	79.5
"	2—2	.34	140,000	1.91	Yoke bolts, 200,000	...	14,100	11,900	85
" (wood)	2—3	.52	140,000	2.03	Sills crush, 255,000.....	.25	13,400	10,900	81
"	2—4	.46	140,000	2.11	Sills spreading, 220,000.	.46	12,500	10,100	81
Sterlingworth (steel) ...	4—1	.24	290,000*	2.0	At 300,000; no failure..	.81	15,200	10,200	67
" " ...	4—2	.35	240,000*	1.9	At 250,000; no failure..	.17	11,000	5,580	50.5
Thornburg (steel)	5—2	.52	.....	....	Casing cracked, 200,000	.77	12,780	10,300	80
Butler (steel)	6—1	.79	230,000	2.6	Friction plate bent	.63	13,800	11,400	83
"	6—2	.87	220,000	2.02	Yoke bolts bend'g, 260,000	.4	.....	9,500	78
" "	6—3	.69	130,000	1.52	Friction plate bent, abt 180,000	.35	5,450	3,450	63
" "	6—4	.83	140,000	1.76	Friction plate bent, abt 180,000	1.21	6,250	4,100	66
Hinson (steel) .....11—1		1.16	60,000	2.05	At 300,000; no failure..	.19	.....	.....	..
" " .....11—2		1.88	50,000	1.98	Main bolt bend'g,100,000	.31	3,950	2,650	67
" (wood) .....11—3		1.81	130,000	2.27	Sills crushing, 180,000..	.57	5,800	1,790	31
" .....11—4		1.9	100,000	2.28	Crushing at upper bearing sill plates,140,000	.6	5,230	1,780	34
" " .....11—5		1.66	110,000	2.02	At 260,000; no failure..	.07	4,450	2,900	65
" " .....11—6		1.61	140,000	2.43	....	.68	6,500	4,400	67.5

*About.

work) between the compression line and the release line. The elements are listed in case of the gears tested in Table I.

(2) Load at Failure.—It may be said that only in some cases does the load at failure in the tests below have any connection with the strength in service, for the reason that the attachments used in the tests are not under the same action that exists in the case of these attachments in car construction. That is, there was a tendency for the sills as used in the tests to fail by buckling slightly, thus throwing the bearing mainly on one edge of the sill. This was attended with a crushing of the sills where they bore on the platform of the testing machine at a load under which the lug bearings on these sills and the coupler attachments were unharmed. It is thought that the sills in the car under service are not subjected to the same strain as in the tests. However, in many cases, the failure under test was due to crushing of lug bearings on sills, bending of follower plates or housings, and these are to be classed as true failures of the rigging distinct from the failure due to the method of support in test.

METHODS OF MEASUREMENT ON TEST.—The testing machine used was the 300,000-lb. Riehle machine. In the course of the work certain weaknesses developed in



* = Rebound still increasing when Gear failed.

Fig. 3. Diagram Showing Maximum Rebound of 1,640-lb. Hammer with Different Draft Gears.

the running gear which caused delay and made it necessary, in case of the later tests, to limit the capacity of the machine to 250,000 lbs. Subsequently proper repairs were made to the machine. Figs. 1 and 2. The riggings were first subjected to an initial load of 20,000 lbs., and this load released. Loads were then applied in increments, and the machine was stopped to read the movement of the yoke. In case of one friction rigging a comparison of tests was made between results from continuous running and loading at intervals. No difference in the resulting curve, due to difference of rate of loading, could be found. It is possible, however, that a rapid action in service or an impact action might show slightly different form of diagram in case of friction gears. The movement of the yoke was determined with reference to the sills, and this movement includes any failure throughout the rigging, whether of follower plates, lugs, housings of lug bearing. In case of tension tests, this movement was read from a scale attached to a crosspiece fixed to the sills slightly below end of the yoke, and in case of compression tests, the scale was supported directly on the bed of the testing machine. In some cases a two-fold multiplying device was used. After tests, the riggings were opened up and their condition examined.

RESULTS.—The results of the tests are shown in Tables I. and II.

FORM OF GOVERNMENT OF THE DISTRICT OF COLUMBIA.

Among the papers presented to the American Society of Civil Engineers, at its late annual convention in Washington, D. C., was one outlining the form of government of the District of Columbia. The writer of the paper was Major Wm. M. Black, Engineer Corps, U. S. A., and former Engineer Commissioner of the District; and as the government of this area is unique in its organization, the following abstract of his paper is given.

The present form of government in the District was established by an act of Congress approved June 11, 1878, with some very slight modifications since that date. The executive, and to a minor degree, the legislative functions of the District are placed in the hands of three commissioners; two of whom are civilians and the third an officer of the Engineer Corps of the United States Army. The civilian commissioners are appointed by the President of the United States and their appointment is confirmed by the Senate; they are ordinarily selected one from each of the two principal political parties. At the time of their appointment they must be citizens of the United States, and for the three preceding years they must have been actual residents of the District of Columbia. The third commissioner is detailed by the President from the Corps of Engineers, and he must hold rank not below that of Captain, and have seen at least fifteen years' service.

These commissioners act as a Board, the Civil Commissioner of the same political affiliations as the President ordinarily acting as president of the board. Any two commissioners constitute a quorum in the transaction of business. The Engineer Commissioner is entitled to not over three assistants detailed from the Corps of Engineers; the senior of these acts as Engineer Commissioner in the absence or disability of his superior officer. The judicial system of the District is entirely distinct from this board, the judges being appointed by the President of the United States.

Under general laws enacted by Congress the commissioners are empowered to make regulations, corresponding to ordinary city ordinances, relating to police, health, building, plumbing, etc., and to provide for their enforcement. Congress also provides specifically for the more important of the subordinate officials, and in the annual appropriation bills the number and salaries of the permanent employes are rigorously fixed.

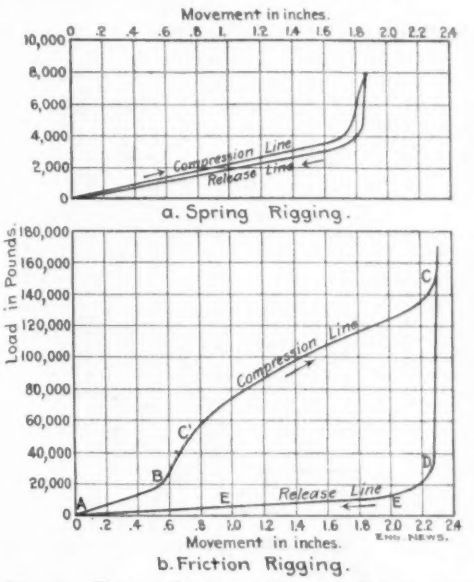


Fig. 4. Typical Diagrams Showing Compression and Release Lines Obtained in Testing Draft Riggings.

The expenditure of the District is met by taxation, regulated by Congress, and leaving free from taxation all government property. The Commissioners annually submit to the Secretary of the Treasury and to Congress, detailed estimates of expenditures and such recommendations as they deem of public interest. To the extent that these estimates are approved by Congress 50% is appropriated out of the Treasury of the United States and 50% is raised by taxation in the District. In late years, however, Congress has from time to time provided that certain definite works should be paid for wholly out of the revenues of the District.

The duties of the District Commissioners are outlined as follows by Major Black:

Civil Commissioner.—Jurisdiction over charities and hospitals, educational questions, public health and safety, other than police and municipal engineering, fire department, street lighting, use of electricity, markets, excise, weights and measures, harbormaster.

Civil Commissioner.—Jurisdiction over taxes and assessments, law department, auditor's office, property department, street and alley cleaning, collection and disposal of garbage, police department.

Engineer Commissioner.—Jurisdiction over the engineering work of the District under the supervision of two assistant engineer officers of the Army, with assistant engineers or superintendents as follows:

Assistant Engineer Officer.—Streets, pavements, grades and construction of roads.—Computing Engineer.

TABLE II.—Showing Results of Tension and Compression Tests on Spring Draft Gears.

Rigging.	Series No.	Movement of yoke at 20,000 lbs. in ins.	Load when solid, in lbs.	Movement when solid in ins.	Final set in.	Load at failure, in lbs.	Total work in ft.-lbs., in spring action.
Thornburg (steel)..	3—1	1.01	35,000	1.59	0.515	Spring housings (steel), bent about 180,000	2,314
" " ..	3—2	1.12	35,000	1.72	.77	Spring housings,* failed about 170,000....	2,508
" " ..	3—3	1.0	40,000	1.74	1.14	Spring housing,* failed, about 120,000....	2,900
" " ..	3—4	1.05	35,000	1.65	.53	Spring housings (steel), bent, abt 120,000	2,405
Miner (wood)	7—1	.68	40,000	1.66	.	Test not extended to determine failure....	.....
" "	7—2	.89	30,000	1.56	...	Sill bearing crushing, about 50,000.....	.....
" "	7—3	.86	40,000	1.77	1.2	Sills crushed, 150,000.	2,950
" "	7—4	.92	40,000	1.87	.3	Sills crushing, 120,000.	3,116
" (steel)	7—5	.67	50,000	1.8	.3	Sill channels bend, 280,000.....	3,750
" "	7—6	.86	40,000	1.73	.47	At 250,000; no failure.....	2,883
" "	7—7	.8	60,000	2.43	.11	At 300,000; no failure	6,075
" "	7—8	.8	65,000	2.53	.29	Yoke bolts failed; 240,000.....	6,852
Butler (wood)	9—1	.72	40,000	1.42	.12	At 250,000; no failure.	2,012
Butler (wood)	9—2	.57	40,000	1.51	.34	Sills crushing, about 100,000.....	2,139

*Malleable

Note.—In Tables I. and II. an even number following series number indicates a tension test; an add number, compression test. Failure due to "crushing of sills" indicates that sills crushed at bearing on platform of testing machine. Such failure is not to be charged to rigging, but rather to the test attachments.

Sidewalks and alleys.—Superintendent of Streets.
Maintenance of county roads.—Superintendent of Roads.
Construction and care of bridges.—Engineer of Bridges.
Surveyor's office.—Surveyor District of Columbia.
Parking Commission.—Superintendent of Parking.
Assistant Engineer Officer.—Water Distribution.—Superintendent of Water Department.
Water rates.—Water Registrar.
Sewer construction and maintenance.—Superintendent of Sewers.
Plumbing plans and inspection.—Inspector of Plumbing.
Building and building inspection.—Inspector of Buildings.
Repairs to buildings; wharves; inspection of asphalt and cement; street extension plans; superintendent of property; permit department; record department.

The unique position among municipal governments of the Engineer Department of the District lies in the fact that at its head is an engineer who forms one-third of the governing body, and its membership is in no way dependent upon any political party.

In this department every cent and unit of material is traced and charged to its particular work, and this is done with a minimum of clerical labor. Supplies are bought under annual contracts, made after advertisement for proposals; cement is furnished to the various contractors at a price slightly in advance of the retail market value, and is named in the contracts; bulky materials, such as paving brick, sewer pipe, etc., are subjected to a preliminary inspection at the place of manufacture; and each official in charge of work is held strictly accountable for results in product and costs; and he holds his position only by his proved ability.

The following advances in municipal practice among others should be credited to this department, says Major Black:

The development of asphalt pavements to suit the climatic conditions of this country, and the use with them of vitrified brick gutters with straight joint.

An extended and careful series of long-time tests for asphalt and cements with reference to their municipal uses, including tests of gravel concrete.

The use of vitrified half pipe for the wearing surface at the base of egg-shaped sewers.

The development of an inexpensive concrete sidewalk for general city use.

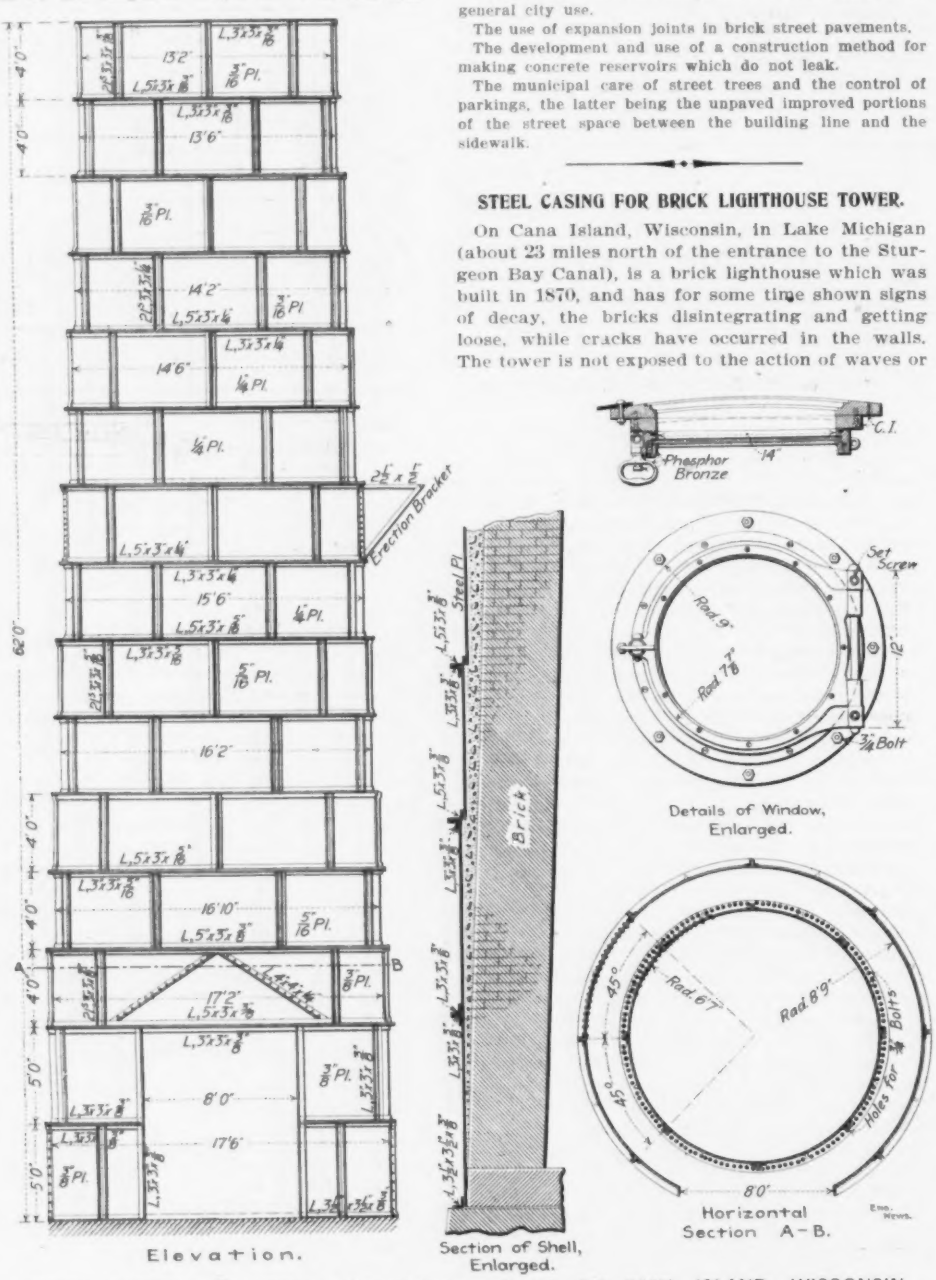
The use of expansion joints in brick street pavements.

The development and use of a construction method for making concrete reservoirs which do not leak.

The municipal care of street trees and the control of parkings, the latter being the unpaved improved portions of the street space between the building line and the sidewalk.

STEEL CASING FOR BRICK LIGHTHOUSE TOWER.

On Cana Island, Wisconsin, in Lake Michigan (about 23 miles north of the entrance to the Sturgeon Bay Canal), is a brick lighthouse which was built in 1870, and has for some time shown signs of decay, the bricks disintegrating and getting loose, while cracks have occurred in the walls. The tower is not exposed to the action of waves or spray in storms, but is exposed to beating rains and hail, and to the effects of the freezing of the surface after winter storms. After considering the reconstruction of the tower and different methods of repair, it was decided to build a steel shell around the tower, and to fill in the space between the tower and shell with concrete. The contract for the metal work of this was awarded to the Indiana Bridge Co., of Muncie, Ind. The erection will be done by day work under the direction of Major J. G. Warren, Corps of Engineers, U. S. A., Engineer of the Ninth Lighthouse District, at Milwaukee, Wis. The 100-ft. lighthouse tower at Grande Point au Sable, Michigan, was thus treated about two years ago, after designs by Mr. Edward L. Woodruff, M. Am. Soc. C. E., Assistant Engineer of the District. Other lighthouses may also be treated in the same way as this method seems the most economical for the preservation of such structures.



STEEL CASING FOR BRICK LIGHTHOUSE TOWER ON CANA ISLAND, WISCONSIN (LAKE MICHIGAN).

Maj. J. G. Warren, Corps of Engineers, U. S. A., Engineer. Indiana Bridge Co., Muncie, Ind., Contractors.

A concrete shell, without the steel casing, would afford sufficient protection if built of the best materials and in the best manner, and provided that the shell was of sufficient thickness to support itself without the aid of the brick tower. Such a structure, however, would be, in the opinion of the engineers, a much more expensive affair than the steel shell with concrete back. The reasons for using a steel shell were the economy in construction and the smooth surface for painting, which gives a color for distinguishing the tower as a mark by day.

The steel shell consists of horizontal cylindrical courses 4 ft. high, each ring composed of eight segments riveted together in the field at vertical flanges formed by steel angles. The top flange of each course is an angle 3 × 3 ins., while the bottom flange is an angle 5 × 3 ins., so that the diameter of each course is 4 ins. less than that of the one below; the shell thus tapers to conform to the batter of the old tower. The horizontal flanges are riveted together. The two bottom courses are 17 ft. 6 ins. diameter, and 5 ft. high with the bottom flange angle anchored to the stone foundation of the tower, and this bottom section has an opening 8 ft. wide for the covered way or gallery leading from the keeper's house to the tower. Above this the courses are all 4 ft. high, the web plates ranging from ⅜-in. to 3-16 in. in thickness. The total height of the shell, from the base to the gallery around the lantern, is 62 ft., and its diameter is 17 ft. 6 ins. at the bottom and 13 ft. 2 ins. at the top. There are six windows, 14 ins. diameter, hinged to iron frames bolted inside the shell; these will be placed during erection, opposite the windows in the brick shaft.

The courses are built at the shops in separate cylinders, eight segments to each course, and have the vertical flange angles crimped to fit over the top and bottom angles. To carry the erecting platform, triangular brackets are bolted to the vertical flange angles, these brackets being moved upward as each course is completed. The segments are oiled instead of being painted at the shops, being given one coat of pure linseed oil; they are given three coats of white lead paint after erection, the color of the finishing coat being buff.

The material is required to be open-hearth or Bessemer steel, with not more than 0.08% of phosphorus. The plates and shapes are to be of medium steel, 60,000 to 70,000 lbs. ultimate strength, with a minimum elongation of 22%; and test pieces with a sectional area of at least ½ sq. in. must bend 180° to a diameter equal to the thickness of the piece, without any sign of fracture on the outside. The rivets are to be of soft steel, 50,000 to 60,000 lbs. ultimate strength, 26% elongation, and the test piece must bend 180° flat on itself. The rivets are to be machine-driven wherever practicable.

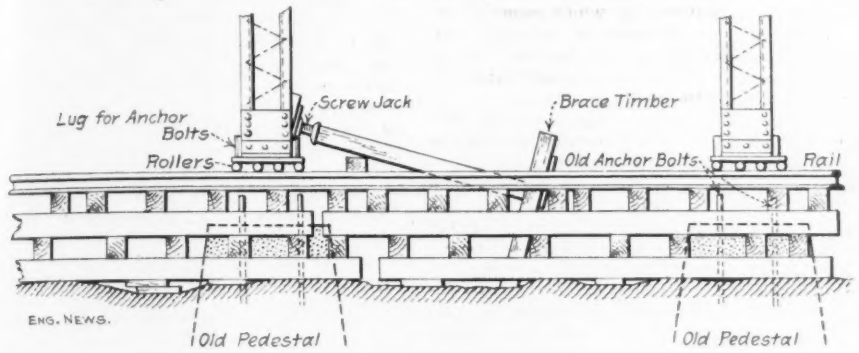
When a few courses have been completed, concrete is poured between the steel and the brick, and rammed in place. This concrete is composed of 1 part Louisville cement, 4 parts fine stone and 3 parts sand. The mixture may consist of 1 barrel of cement, 3 barrels of sand and 20 cu. ft. of crushed stone, which will approximate to the proportions given above.

The work will be done this summer, and the total cost, including the steel shell and its erection, concreting, painting, etc., is estimated at $4,000.

THE EARLIEST TRACK-LAYING MACHINE patent is said to have been that issued in February, 1878, to the late Mr. D. F. Holman, of Chicago. This has now expired, but the Holman machine, modified and improved from time to time, has been used in laying over 9,000 miles of track on more than 100 railways. This information has been given us by Mr. W. L. Cowles, M. Am. Soc. C. E., Secretary of the D. F. Holman Railway Tracklayer Co., of Chicago, in connection with the editorial note on the use of track-laying machines, in our issue of July 10, 1902.

MOVING THE METROPOLITAN WEST SIDE ELEVATED RAILWAY OF CHICAGO.

The Garfield Park line of the Metropolitan West Side Elevated Ry., of Chicago, will form the city connection of the Chicago, Aurora & Elgin Electric line, the latter being a third-rail double-track interurban electric railway designed for high-speed service. It is possible that at some future time the interurban cars may be run over the elevated railway to the center of the city, but at present no such arrangement is contemplated, and there will be a surface transfer station at 52d Ave. To reach this station, the elevated railway company has built an incline, with a grade of 0.9%, from its present station at 48th Ave., this incline being a double-track deck structure with four lines of plate girders supported by transverse plate girders on two rows of steel columns with concrete pedestals. The structure is very rigidly connected and braced. There are 24 spans of 45 to 50 ft., followed by a through plate girder bridge over 51st Ave. At the time the structure was built the company could not get the right to cross certain property on 48th Ave., and instead of building a straight line it was necessary to divert the east end about 40 ft. to the north, and then approach the direct line at an angle. This necessitated awkward reverse curves at the east end connection with the elevated railway, these curves being located on the first three spans of the incline. As it was understood that the desired right of way would eventually be obtained and the structure shifted to form a straight extension of the elevated railway, provision for the reduction in length on the new location was made by extra plates spliced on the ends of the girders of the spans carrying the curve.



MOVING THE STRUCTURE OF THE METROPOLITAN WEST SIDE ELEVATED RY.; CHICAGO.
W. S. Menden, Chief Engineer.

The necessary right of way was obtained sooner than had been expected, and as the interurban railway is not yet open for traffic, it was decided to shift the incline at once. This involved the moving of 22 spans, including the three spans for the curve. New concrete pedestals were built for the column foundations, with anchor bolts set in place. The three spans on the curve were cut apart to allow of removing the end panels, as already noted, so as to leave these girders of the proper length for the straight spans. These three spans were supported by timber bents, with 6-in. wooden rollers between two lines of sills, and they were moved independently of the rest of the structure.

The overhanging east end of the first straight span (a span No. 4), being cut away from the transverse girder, was supported by cribbing which rested upon sills and wooden rollers. This end had the maximum travel of about 40 ft. to the new position. At the west end of span No. 22, where the movement was zero, the splice joints over the columns were cut, and the ends of the girders of this span were braced by struts against the south side, so that the structure would practically pivot on this point. In preparing to move these 19 connected spans, the nuts on the anchor bolts of the old pedestals were removed, and the structure then jacked up about 18 ins. to clear these bolts, which passed through plate lugs riveted to the side webs of the columns.

Blocking was then built between the old and new pedestals at each bent, this consisting mainly of 6-in. and 8-in. timbers, and upon this were laid two lines of 80-lb. rails about 12 ins. apart. Three or four 2-in. iron rollers were placed under the ⅞-in. base plate of each column. This being all done, the structure was ready for moving. To accomplish this, ordinary house-moving screw jacks were used, the screw lying in a hollow timber. These jacks were butted against shims on the inner side of the line of columns nearest to the new position, so that these columns and their connections pulled the structure with them. The jacks were slightly inclined and were butted against the ends of inclined timbers braced inside of the blocking.

The whole section of 19 connected spans was moved over as one piece, sights being taken along the columns to ensure that the structure was not buckled. The west portion, with the lesser movement, was first partly moved, and then the east ern portion; these portions were worked alternately, keeping the structure practically in line. On the portion being moved there was one man to each bent, working the jack, while extra men helped at the various bents when the jacks and jack timbers or rollers had to be shifted and adjusted. The maximum movement was about 40 ft. at the east end, decreasing at each bent until it became zero at the west end. The last two spans (connecting with the 51st Ave. bridge) were left undisturbed. When the columns were in position, they were adjusted so that the holes in the shoes and anchor brackets would fit the anchor bolts, and the columns were then lowered upon the new foundations.

The contract for the entire work was awarded to Grace & Hyde, of Chicago, who sublet the work of moving the structure to Rector & Co., also of Chicago. The moving was commenced on July 25 and completed in a few days, the work not being hurried, as the line was not ready for traffic. The entire work of changing the line occupied about two weeks.

A similar piece of work was done on the Douglas Park line of the same elevated railway last year, about 600 ft. of the line being shifted so as to take out a reverse curve. In both these changes the work was planned by and executed under the direction of Mr. W. S. Menden, Chief Engineer of the Metropolitan West Side Elevated Ry. Besides these changes, the structure has been raised bodily at certain parts of the line, on account of the track elevation work on some of the steam railways which the elevated lines cross. An important piece of work of this kind was described and illustrated in our issue of Sept. 30, 1897.

NOTES FROM THE ENGINEERING SCHOOLS.

PURDUE UNIVERSITY.—A full-sized model, complete in every detail, of an early locomotive has just been presented to Purdue University through the courtesy of Mr. R. P. C. Sanderson, Superintendent of Motive Power, and Mr. J. M. Barr, General Manager, of the Seaboard Air Line Ry. The model is a copy of the "Tornado," the second locomotive owned by any of the original roads composing the present Seaboard Air Line Ry. The "Tornado" was purchased in England, and in March, 1840, was placed into service in this country. It had a single pair of drivers and a four-wheel truck under the engine, with a four-wheel tender; the firebox was cylindrical.

AN OIL-WELL PUMP-ROD JOINT PROTECTOR.

A considerable portion of the petroleum produced in this country, and especially in California, comes from so-called pumping wells, which may be from 500 ft. to 3,000 ft. deep. In these wells the pump is located at the bottom, and it is worked through the medium of a chain of pump rods operated from the surface by steam power; each stroke of the pump rod raising and lowering a valve and forcing the oil up through the lining or tubing in which the pump rod is confined for its entire length. These pump rods are joined by screw couplings, and these joints wear out rapidly owing to several causes. The first of these is the sand contained in the oil, which in some cases will scour out the joints in a few days, wearing out the thread, and, unless carefully watched, causing the pump rod to part, with all the attendant difficulties and cost of recovering this rod by the use of "fishing tools." The second cause is the not generally recognized fact that no well is or can be bored perfectly vertical; there always are some slight bends in the bore, and at each of these bends there is friction between the pump rod joints and the tubing, causing a more or less rapid wear in both joints and tubing.

An Anti-Friction Joint for Oil-Well Pump Rods. W. G. Leale, San Francisco, Cal., Inventor.

To obviate the excessive operating cost resulting from these causes, Mr. W. G. Leale, of San Francisco, Cal., has devised a very simple protector, to be placed between the jointed pump rods. It is, in fact, a short extra section of pump rod, threaded to connect two 20-ft. lengths of main pump rod; and in this short section are two small metal friction wheels, set at right angles to each other and projecting sufficiently to bear against the sides of the tubing. By this device the wheels roll on the tubing and no scour or friction can come upon the threaded joints.

The protector has been practically and successfully tested in some very sandy oil wells in the Bakerfield oil region of California. One user testifies that the pump rods in his well formerly wore out in from two to seven days, involving a loss of from 12 to 15 rods each time, and costing him in money about $100 per month, not including loss from cessation of pumping or from wear on tubing. After two weeks' continuous use with the protectors, the pump rods and protectors showed little or no wear, and his engineer reported a considerable decrease in the power required for pumping.

This protecting device, known as the Leale-Vinzent Pump-Rod Protector, is being placed upon the market by the W. G. Leale Manufacturing & Development Co., of 137 Montgomery St., San Francisco, Cal.

AN ALUMINUM AUTOMOBILE has been made by G. M. Quimby & Co., of Newark, N. J. The aluminum body is fitted with a 16-HP. Panhard motor, imported for the purpose. The advantages claimed for the use of aluminum are strength and lightness; this tonneau body weighs less than 150 lbs.; though it has a seating capacity for seven persons—an ordinary body with one seat weighs 75 to 80 lbs. Aluminum can also be shaped into beautiful and graceful designs, and any coloring can be applied.

A PERMANENT WESTERN MEXICO EXHIBITION is to be established at Guadalajara, State of Jalisco. It is to be opened by the President about Aug. 15, and manufacturers from the United States have been invited to exhibit, and about 50 firms from St. Louis alone have responded. Guadalajara is the center of a rich agricultural district, and is the distributing point for the mining and fruit-growing districts of the West coast.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

One of the greatest obstacles in the way of extending the meter system in many cities is the regulation that the owners of property are responsible for the water bills of their tenants. In our issue of July 24, a quotation was made from the Memphis "Scimitar," in which an otherwise foolish argument against meters raised this very point. Now comes the Nashville "American," with the following protest against putting schedule rates in the same category:

> Why should owners of property become bill collectors for the city and be held responsible for their tenants' water bills any more than they should be held responsible for and be forced to collect their tenants' gas bills and grocery bills? The average owner has his hands full collecting rent, why impose this public duty upon him?

This is very much the same line of argument as we employed in the Memphis case, before the Nashville item was received, but the argument is far stronger where meters are involved, since the schedule rates are a fixed quantity and the very object of the meter rates is to provide for variable quantities due to either use or waste, and particularly the latter. With schedule rates, the house-owner has only to add the water rent to the ordinary house rent in order to protect himself, while with meter rents he does not know what to add. Opponents of meters seize on the latter fact as an argument against meters, but it is really an argument against compelling lessors to assume the water bills of their tenants. With the extension of the meter system ways to obviate these difficulties will be found. The simplest, of course, is to collect the meter charges from the consumer, instead of the owner. Where city charters or contracts with water companies do not permit this practice, perhaps the best that can be done, pending a reform, is to draw all leases so that the tenant will become responsible to the landlord for the whole meter charges, either on presentation of the water bill, or by payment of a fixed sum with the monthly rent and the excess, if any, when the meter bills are rendered. Of course this will not relieve the lessor from responsibility to the city or water company for the full amount of the water bill, but it will merely add to his continual risk for default on house rent a like default on water rent, and where house rent is paid in advance the water bill risk will be only the excess over the constant charge.

On another page of this issue we reprint a paper by Mr. B. J. Arnold dealing with the subject of electric traction on the New York terminal division of the New York Central & Hudson River R. R. The division in question includes the notorious Park Ave. tunnel, best remembered, perhaps, by a rear end collision which occurred in the tunnel last autumn, in which some fifteen lives were lost. The division is somewhat difficult to operate, because at its lower end, Grand Central Station, it terminates in a switching yard much too small for the traffic, so that there is an extensive transfer of empty trains over the division to and from the storage yards at Mott Haven Junction, its upper end. The added traffic is not a serious matter in itself, but becomes important in its bearing on the conditions in the Park Ave. tunnel. This tunnel has long been a public nuisance as well as a notable hindrance to traffic. This is so not because of the tunnel as such, nor because of the unparalleled amount of traffic—railway tunnels with very heavy traffic are not uncommon and give no particular trouble in operation—but the Park Ave. tunnel has entirely inadequate natural ventilation, a condition of things made worse by the peculiar construction of the tunnel (see a drawing in Engineering News of Oct. 17, 1902), and no real attempt has ever been made toward providing it with proper artificial ventilation. Thus the tunnel has for years been a menace to safe operation of traffic over the division, and an inconvenience, even a hardship, to travelers passing through it.

Many plans have been proposed for improving the tunnel. Among these were the operation of the division by compressed-air locomotives; by superheated-water locomotives, or by some method of electric traction; another scheme was to convert the tunnel into an open cut, and still another was to provide the tunnel with a system of forced ventilation. The last-named plan would seem to be the most direct and natural solution of the problem. It has been advocated from many quarters; Engineering News in particular, as our readers will recall, has strongly recommended this plan (Eng. News, July 11, 1901), basing its argument on a full and clear analysis of the issues involved. The railway company, however, has at all times been rigidly opposed to this solution of the question; its aim has been to secure permission for constructing an open cut in place of the tunnel, a proceeding which would have caused an enormous and needless loss to the city in depreciating a great and valuable residence district. The company has seemed no less opposed to electric traction on the Mott Haven Division, on the ground that it would not be practicable unless the entire suburban traffic on the line could also be handled by electricity. When, however, it became evident, a year ago, that no open-cut construction on Park Ave. would be tolerated by the city of New York, the company proceeded to make a study of electric operation. This study, which was carried on unknown to the public, was in charge of Mr. Arnold, and the technical results of his work are summarized in the paper which we reprint.

There are many interesting things about the paper, even aside from its immediate contents. For one thing, it represents an official overture on the part of a large railway corporation toward electricity as a direct motive power on a part of its lines. It also constitutes a thorough and satisfying solution of an engineering problem of considerable importance and of long standing. Probably as interesting a feature of the paper as any other, however, is that the whole investigation was carried out and the report submitted all within the short space of four months. Though ordered in August, the work was delayed from various causes, so that it was begun only in October, 1901; the final report was presented to the railway company in February, 1902. While the situation called for the utmost despatch, it was a matter of surprise even to Mr. Arnold's professional colleagues, that he had been able to accomplish so extensive and important an undertaking as this was in such a remarkably short space of time, and it must be regarded by the whole engineering profession as an achievement worthy of high praise.

LABORATORY DRAFT GEAR TESTS AND THE STRAINS OF ACTUAL SERVICE.

In another column of this issue we record briefly the results obtained by the special committee of the Master Car Builders' Association in a series of tests made to determine the strength of different forms of freight car draft gear under impact and static loads. Two facts stand out prominently in these results. The first fact is that the drop test made by the committee was because of its character comparable only in a slight measure to the actual impact shocks which freight cars receive in service. The second fact is that only in some cases did the load at failure in the tensile and compressive tests indicate at all the strength of the same draft gears in service, for the reason that the attachments used in the tests were not under the strains that they are subjected to in actual service.

At first sight it may seem from these statements that the work of the committee has been performed to little purpose. To be perfectly frank, the results of the committee's tests are somewhat disappointing, but it is unfair, because of this fact, to draw the hasty conclusion that they are of no value. They at least demonstrate the limitations of laboratory tests and the need for a more careful method of conducting such tests within the limits of their usefulness; they also demonstrate fairly the inadequacy of certain details and materials which the manufacturers will be glad to improve, now that their weakness is known. At best, laboratory tests of draft gear will never be more than a check upon the material and design of the attachments under consideration. They can offer hardly any reliable information of the relative merits of two gears of different type, or even of two different designs of the same type of gear. No test but that of actual service can afford this information.

Just how far short of the shocks of actual traffic the drop tests made by the Master Car Builders' committee fall is well brought out by a committee report published in the May "Proceedings" of the Western Railway Club. This report recounts in considerable detail the pulling and buffing strains recorded by a dynamometer car made up with regular trains in actual service. Its principal contents may be summarized briefly as follows:

Two series of tests are recorded. The first series was conducted on the Lake Shore & Michigan Southern Ry., and comprised 34 trips, aggregating 2,512 miles. Some of the trips were made on the main line, where the grades did not exceed 0.3%, and others were made on a branch line having maximum grades of about 1%. The dynamometer car was one especially designed for tests of this character, and it had a nominal measuring capacity of 300,000 lbs. The locomotives used in the tests were of the consolidation type, having a total weight of 175,000 lbs., of which 155,000 lbs. were on the drivers, and a tractive force of 36,000 lbs. The cylinders were 21 × 30 ins. and the steam pressure was 200 lbs. The trains were handled as in ordinary traffic, but by engineers and trainmen who had been trained to use care in avoiding heavy pulling and buffing shocks in performing their work. The second series of tests were made on another road, where the men handled the trains roughly. It should also be noted, perhaps, that in the first series of tests spring draft gears were used, and in the second series the draft gear was of the friction type.

So much for the character of the tests made. The results obtained were, in brief, as follows: With a skillful engineer the tensile and buffing

strains seldom exceeded 50,000 lbs. and 80,000 lbs. respectively, but with a less skillful handling of the trains these strains increased to 70,000 lbs. and 150,000 lbs., respectively. The significant feature of these general figures is the proof which they furnish that care in handling trains is a matter of extreme importance. These figures, however, do not tell the whole story, as may be seen from the following extract from the committee's report:

"The most ordinary movement in coupling up engines and cars, even if performed with care, results in heavy buffing shocks. An engine coupling on to its train gives stresses ranging from 65,000 to over 142,000 lbs.; a switch engine coupling onto the dynamometer car standing alone gives a stress of 103,673 lbs.; when a string of loads was behind the car the switch engine coupling on gave a buffing shock of 199,482 lbs.; and 30 loaded cars moving at about 6½ miles per hour and coupling on to ten loads with brakes set gave a shock of 376,492 lbs. After the completion of a certain trip, the train was placed on the receiving track in the poling yard, and the dynamometer car being on the head end, the first operation was to pole it onto a track that was supposed to be clear. There was, however, a loaded 60,000-lb. furniture car standing on the track, and the dynamometer car struck it at a speed of 12½ miles per hour. The apparatus in the car recorded 281,704 lbs., which was its limit. What the actual shock was cannot be told. A coupler was broken and some slight additional damage was done. The car was new, which doubtless explains the small damage done.

"From the general results of the tests it is believed that the tensile strains in draft gears with careful handling will frequently reach 50,000 lbs., with ordinary handling 80,000 lbs., and with decidedly rough handling fully 100,000 lbs., while the buffing strains can be placed at 100,000, 150,000 and from 200,000 to 300,000 lbs. respectively. In extreme cases the buffing strains will go considerably above the last-named figure. It will undoubtedly require more extensive tests to determine whether these figures need modification, but it is evident that the tests give us a more definite idea of the strains which draft gears and sills must stand than we have been able to obtain heretofore. Continued investigation along these lines should finally result in a sufficient amount of information to permit a more exact method in the designing of draft gears."

In commenting upon these figures, it is fair to say, we think, that very few railway motive power officials have appreciated that their car framing and draft rigging were being subjected to any such strains in actual traffic. In fact, we think that many of them will still question the statement that buffing shocks closely approaching 200 tons actually occur under the by no means exceptional circumstances cited by the committee in the quotation from its report which we have printed. With no more details than the report gives upon which to base judgment, we are inclined to question the entire accuracy of the dynamometer record of such enormous impact loads. Is it not quite likely that the momentum of the recording apparatus, moving suddenly under the shock of colliding cars, has resulted, by a jump of the pen in these instances, in a false record? A point of evidence which suggests this possible was given by Mr. E. M. Herr, who witnessed the tests. Mr. Herr stated, in discussing the report, that the heaviest blows were never sustained; the blow came with great suddenness and was over at once, as shown by the recording pen. The blows below 100,000 lbs. were, however, frequently sustained an appreciable length of time.

If we accept at their full face value the figures of the report, it is plain that railway motive power and operating officials have a rather serious problem before them. The committee itself concludes that these figures show the necessity of something better and more effective than the spring draft gear so commonly used. In its opinion, it would be reasonable, in view of the figures given, to require draft gears and under-frames to be capable of withstanding tensile strains of 150,000 lbs. and buffing strains of 500,000 lbs. This is putting a rather heavy burden upon the car builder and the manufacturer of draft gear. Are we certain enough of the figures cited to warrant us in going so far as to demand these capacities of them? Furthermore, is it not equally reasonable to demand that trains be handled more carefully?

According to the figures given, the pulling and buffing shocks, when a train is roughly handled, are from two to three times as great as they would be if the train were carefully handled. Why should the car structure be made to bear alone the burden of carelessness? The exceptionally heavy shocks quoted in the committee report resulted from conditions which are not necessitated by the objects sought. To back into a train of loaded cars with their brakes set at a speed of 6½ miles per hour is not necessary in order to make a coupling; nor is it justifiable to mistake an obstructed track for a clear one, and, therefore, smash one car into another at a speed of 13½ miles per hour. There is evidently no insuperable obstacle to the operation of trains so that the pulling and buffing shocks will in nearly all cases come far below the maximum figures quoted. Instead, then, of assuming that the car structure should be designed to withstand these enormous shocks, it would seem a wiser plan to class these exceptional shocks as accidents and to charge the trainmen with the blame and punishment for them.

LETTERS TO THE EDITOR.

The Performance of the Dredge "J. Israel Tarte."

Sir: I observe in a notice which you have in last issue that you refer to me as "Chief Engineer of the Bucyrus Co., South Milwaukee, Wis." I would like to state that I am no longer connected with the Bucyrus Co. You also state that the performance of the dredge as quoted is as estimated by the Montreal "Herald," which naturally is not very reliable. For your information I will say that the official engineer's estimate of the work of this dredge for the week ending July 12th is 106,925 cu. yds. This was done in six days and four nights and in blue clay in 36 ft. of water delivered 2,000 ft.

Yours very truly, A. W. Robinson.

Montreal, Canada, July 26, 1902.

The Voids in Sand.

Sir: Your correspondent "Civil Engineer" in Engineering News of July 10 brings up a question concerning the percentage of voids in sand which is not new to those familiar with concrete construction and which indicates the errors into which this method of specification of concrete proportions may lead those unfamiliar with the nature of sand.

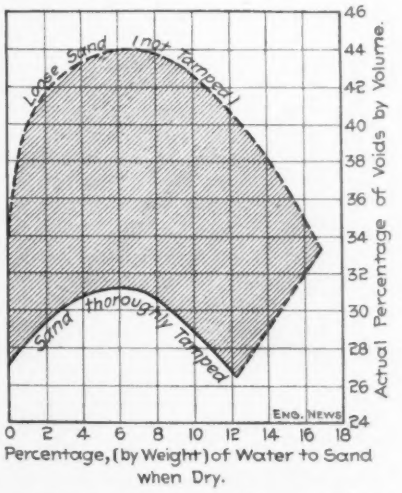

Loose Sand (not tamped)
Sand thoroughly tamped
Actual Percentage of Voids by Volume.
Percentage, (by Weight) of Water to Sand when Dry.
ENG. NEWS
0 2 4 6 8 10 12 14 16 18
24 26 28 30 32 34 36 38 40 42 44 46

Diagram Showing Variation in Volume of Voids in a Sample of Sand When Containing Various Percentages of Water and When Loose or Thoroughly Tamped.

The percentage of voids in sand depends on the compactness of thes and and this compactness in its turn depends on other conditions, two of which produce great variations, namely, the amount of tamping of the sand and the percentage of water present in the voids of the sand before such tamping.

Furthermore, unless great care is taken, large amounts of air are entrained in a sand during the process of measuring the amount of voids as indicated by "Civil Engineer," and such measurements become worthless by indicating a percentage of voids entirely too low. The sand should always be poured very slowly and gently into the water, and, under no circumstances, should the water be poured into the sand. I have found that a failure to appreciate this entrainment of air entirely vitiates the use of such method of measuring voids as a field method.

As it is very difficult to find natural sand graded to a percentage of saturated voids as low as is given in the example quoted by "Civil Engineer," I would suspect the presence of entrained air in the sample.

The writer has made many experiments on different grades of sand with varying percentages of voids and the diagram illustrates the results obtained from one sample of sand having a percentage of voids somewhat similar to that reported by "Civil Engineer." As can be seen by a study of this diagram, a single sample of sand, by varying the tamping from loose to hard, and the percentage of water from zero to saturation, irrespective of difficulties in measurement due to entrained air, can be made to show almost any percentage of voids a wily contractor desires.

Wm. B. Fuller.

Paterson, N. J., July 24, 1902.

Sir: I submit the following answer to the query by "Civil Engineer" in your issue of July 10, relative to voids in sand. Assuming that the sand is to be used for cement mortar and specifying a perfect mixture, the voids of the sand must be filled with neat cement mortar. Owing to the supporting power of the neat cement mortar, there will be no settling of the sand such as takes place when water only is intermingled. As sand is loose before mixing, it is obvious that 0.342 cu. ft. of neat cement mortar must be mixed with 1 cu. ft. of loose sand to obtain 1 cu. ft. of perfectly mixed cement mortar. The voids in this instance are accordingly 34.2%.

Respectfully, Claude W. L. Filkins.

Ithaca, N. Y., July 16, 1902.

The Grand Ave. Bascule Bridge at Milwaukee.

Sir: In answer to Mr. Vallee's criticism (Eng. News, July 17) of the Grand Avenue Bridge: The tendency of a column loaded eccentrically is to bend sideways and in figuring such member of a structure, it is a simple problem to allow enough material to make it as safe as if the load was directly applied to the center of gravity of the section. The same is true of the foundations for the Grand Ave. Bridge. The maximum load comes 7 ft. 5 ins. from the front of a 32-ft. pier, but care was taken to place under that point more piles than in the rear and in such a number and so grouped that the load per pile is the same for the whole structure. Hence there is very little possibility of an uneven settlement of the foundations. None has taken place since the bridge is in operation, for the asphalt roadway and cement sidewalks of the approaches would then show cracks over or around the old abutment.

The main girders were not all of the same length when shipped from the shops, which accounts for a bigger clearance, between their ends, at the center lock on one side of the structure, than on the other.

Contrary to what has been asserted, nothing falls on the machinery when the bridge is opened, for wooden coverings have been provided long ago.

I had a look at the trunnion boxes a few days ago and found Mr. Vallee's statement that the babbitt had shifted under the enormous pressure, to be incorrect. Oiling is now just as easy and effective as on the first day the bridge was in operation. The bridge can be opened at 84 in less than half a minute, with only 14 HP.

An air buffer with a well-regulated valve is much better than a block of oak if the tenders, for some reason, lose control of the bridge in closing it. But a careful tender I admit, could easily get along without an air buffer. The break in the floor of the Grand Ave. Bridge being back of the trunnions, a heel lock is useful, if not absolutely necessary.

The first day this bridge was opened for traffic, I was standing at the center of the bridge, with a foot on each leaf during a fire run; engines came along thundering on the structure, sometimes two abreast, but could hardly feel any vibrations; and the heel and center locks had not then been placed.

The 7-ft. gear is a split one and can be easily taken out and repaired or replaced.

The bolting of the main racks under the bottom flange of the main girders instead of alongside of them, would have been a more economical and ideal way of operating the bridge, but it would have brought the remainder of the machinery dangerously near the protection piles. That point was well studied when the operating machinery was designed.

In each pier a wrought-iron pipe has been built, reaching to the bottom of the catchbasin, by which the pits can be pumped dry.

In answer to the other points of Mr. Vallee's criticism I would say that this whole structure was designed by the Wisconsin Bridge & Iron Co., according to the very rigid and up-to-date specifications gotten up by the city engineer of Milwaukee, and that all details were looked into and approved by him or his representative.

The width of channel was approved by the U. S. Government and has proved amply sufficient.

Finally, the bridge stands, and has given entire satisfaction so far. Yours truly,

Alvin Gravelle, C. E., Assoc. M. Am. Soc. C. E.

Milwaukee, Wis., July 25, 1902.

Loss of Head in Flow of Water Through 2½-in. Fire-Hose.

Sir: In view of Mr. Harkness' letter in your issue of July 17, relating to the drop in pressure between the hydrant and the base of play-pipe in a 2½-in. fire-hose (horizontal) provided with a 1-in. nozzle, during the steady flow of water therein, it seems worth while inquiring as to the probable nature of the phenomenon in the case of hose much longer than the longest (1,500 ft.)

used by Mr. Charles in the experiments under consideration. (See your issue of July 3, p. 24.)

Mr. Harkness' relation

$$P = 100 - 2.15\ ^{1}L \text{ (or } P' = 2.15\ ^{1}L)$$

is evidently the equation of a parabola formed by plotting the values of L (length from hydrant to base of play-pipe, in feet, in any experiment) as abscissae and the corresponding (computed) values of P (pressure in pounds per square inch above the atmosphere, at the base of play-pipe) as ordinates. This parabola is shown in the accompanying figure, as CN; A represents the hydrant and B the base of play-pipe; CD, parallel to OX, is the geometrical axis of the parabola.

The special point that the present writer would like to emphasize is that, whatever the nature of this curve may be in other respects, it is of necessity asymptotic to the axis OX (and therefore cannot cross it; though always approaching it); for the actual pressure at the base of play-pipe must necessarily be greater than that of the atmosphere so long as a steady flow is maintained, however small the discharge becomes as L is increased. It is evident, therefore, that a parabola is not the true curve, although Mr. Harkness has shown that the parabola in the figure approximates the true curve for values of L not exceeding 1,000 ft. and serves every practical purpose within that range. The point N' has been plotted from the observed value of P for L equal to 1,500 ft. and the parabola is seen to pass considerably below it.

Now if the loss of head between A and B, and hence P' itself (this loss of head being, of course, proportional to P'), could be expressed accurately as a continuous mathematical function of L and of V, the velocity in the hose (such as P' = a constant multiplied by $L V^{1.6}$), we could combine this relation with that obtained by applying Bernoulli's Theorem to B and m, viz. (corrected for friction):

$$\frac{V_m^2}{2g} = \left[\text{about } 0.94\right] \times \left[\frac{144\ P}{w} + \frac{V^2}{2g}\right]$$

(in which w is the weight in pounds of a cubic foot of water; V_m the velocity of the jet leaving the nozzle, in ft. per second; and g, 32.2) and finally, after employing also the "equation of continuity,"

$$\frac{\pi}{4}(2.5)^2\ V = \frac{\pi}{4}(1)^2\ V_m$$

obtain P as a function of the one variable L. This final function would probably be rather complicated, but would bring out the fact that P could become zero only for an infinite value of L.*

Mr. Harkness, having his parabola in view, and prolonging it far beyond the range of the experiments until it crosses the axis OX (as it inevitably must for some finite value of L) goes on to say:

> This formula seems to indicate that an initial pressure of 100 lbs. per sq. in. would be completely used up by friction in a line of hose about 2,200 ft. long.

It seems difficult to take this sentence seriously, on account of the contradiction involved. If the hydrant pressure of 100 lbs. is "completely used up" by friction when the water arrives at the base of the play-pipe there would be no pressure (above atmosphere) at the latter point to account for the increase of velocity that is to be brought about in steady flow when the water reaches the open air, in the jet; consequently there should be no flow; or, in other words the state of the water would be hydrostatic, which implies that the pressure is 100 lbs. along the whole length of the pipe; since without flow there can be no loss of head. Bearing in mind the principles governing the steady flow of water in pipes, the writer sees no reason why a steady flow cannot be maintained in a horizontal hose of any length whatever, with a pressure of just 100 lbs. at the hydrant and a 1-in. nozzle on the play-pipe. Sincerely yours,

I. P. Church.

Ithaca, N. Y., July 21, 1902.

*The above assumption, $P' = \text{const.} \times L\ V^{1.6}$, leads finally to the relation: $100 - P = C' L P^{0.6}$, where C' is another constant.

The Arches of Westminster Bridge in London.

Sir: With reference to the "Westminster Bridge, London," controversy, which appeared in Engineering News of June 26, no one seems to have cleared the air, although the issue hinges on the fact that the *old* Westminster Bridge was quoted by the author of the article and had your London correspondent said so the matter would have been cleared up. Of course the present bridge which replaced the one in dispute was no doubt erected over the site occupied by Labelye's bridge. I find in an old work on "Bridges" that the particulars quoted by the author are correct as to the *old* bridge excepting the spans, the center one alone being 76 ft., the others decreasing on each side 4 ft. per arch with reference to the large arches (13 in number) thus making the last arch 52 ft. span between piers; the smaller arches are 25 ft. span as given. All were semicircular, the rise being half the span in each. The foundations were laid by means of caissons, one of the piers suffering a slight settlement owing to the removal of sand from the bed of the river. This bridge was opened in 1750; cost £218,800, and the resident engineer was Mr. James King. The centers consisted of braced semicircular framing supported each side on piling and were considered very light in construction. If my memory serves me I think Cresy's "Encyclopedia of Engineering" contains particulars of the *old* bridge and also illustrates the type of center employed; as I have not a copy to hand of the above I cannot vouch for the same. Unfortunately, the mistake has occurred by ignoring the fact that the bridge in question was replaced by a more modern iron structure just as in the same way the bridges at Kew and Vauxhall are now being replaced by later structures—one being a concrete arch type.

The tendency of the engineering profession toward extended use of concrete construction in its varied applications is most marked, though many of its possibilities are as yet vague and undefined. The ease with which it can be handled and worked into divers forms enhances its utility as a constructive medium. The method of strengthening the construction by imbedding steel in the concrete, common to the various systems in use, points to a fact that such reinforcement adds an unknown amount to its strength, let alone its protective value; the corrosion of metals such as iron and steel constantly presents to our minds that nature destroys as well as she creates power unlimitable. One instance of this corrosion the writer would quote: that of an iron pier on the east coast here, just finished, where already the destructive action of salt water and sea air has trade-marked the cast-iron piles and tie-rods to an alarming extent, considering the newness of the structure. Had these piles and details been surrounded with a concrete envelope neatly molded around same, say 2 ft above high-water mark, this continual corrosion might be stayed, or at least warded off for a time, thus preserving the structure. I am unaware, however, whether such protection would stand the concussive action of wave force. Yours truly, J. A. S.

Cambridge, England, July 10, 1902.

Sir: Engineering News of June 26 contains letters to the Editor in regard to Westminster Bridge, London, England. Mr. Luten's authorities and also Appleton's Cyclopedia speak of the bridge as still standing, while the London writer does not seem to be aware that there ever was such a bridge. Samuel Smiles in "Lives of the Engineers," Vol. II., "Smeaton and Rennie," p. 69, gives a short history of the bridge which may be of interest to your readers. He does not give the number or dimensions of the arches.

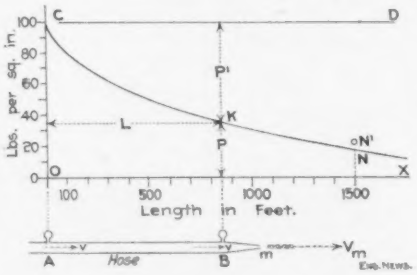


Diagram Illustrating Discussion on Loss of Head in 2½-in. Fire Hose.

The second bridge across the Thames was built in 1738-50, nearly opposite the palace of Westminster. During the many centuries that had elapsed since old London Bridge had been erected, the science of bridge building had made but little progress in England. The principal structures were of wood. Few were built of stone, and these of a comparatively rude kind. During the period referred to, however, the science of construction had made great progress in France, and from the practice of French engineers our best models continued for some time longer to be drawn. Hence when the sanction of Parliament was at length obtained for a second bridge across the Thames, Labelye, the French engineer, a native of Switzerland, was employed to design and execute the work.

It will have been observed that the chief difficulty with the early bridge builders was in securing proper foundations for their piers. A common practice was to sink baskets full of stone in the bed of the river, and on these, when raised above water, the foundations were laid. But where the bottom was composed of loose, shifting material, such as sand, it will be obvious that a firm basis could scarcely be secured by such a method. The plan adopted by Labelye, though considered an improvement at the time, was even inferior to the method employed by Peter of Colchurch in founding the piers of old London Bridge in the thirteenth century. For, clumsy though the latter structure was, it stood more than 600 years, whilst Westminster Bridge had not been erected a century before it exhibited signs of giving way, and it is already destroyed.

Labelye's method of founding his piers was as follows: He had a sufficient number of large caissons or watertight chests, prepared on shore, of such form as to fit close alongside of each other. They were then floated on rafts over the spots destined for the piers, where they were permanently sunk. The top of each caisson, when sunk, being above high-water mark, the masonry was commenced within it and carried up to a level with the stream, when the timber sides were removed and the pier was left resting firmly on the bottom grating. The foundations were then protected by sheet piling, that is, by a row of timbers driven firmly side by side into the earth all round the piers.

Westminster Bridge was originally intended for a wooden bridge, but the design was subsequently altered to one of stone, Labelye considering it necessary to have a g[reater] weight of masonry in order to keep his caissons at proper level. To add to this weight, the engineer ad[ded] a lofty parapet. Not many years after Westminster B[ridge] had been opened, the London Common Council, in o[rder] to facilitate the passage of traffic across the Thames near to the center of the city as possible, applied to P[arl]iament for powers to construct a bridge at Blackfr[iars] and the requisite act having been passed, the works w[ere] commenced in 1760 and finished in 1769. The arch[itect] and engineer of Blackfriars Bridge was Robert Myln[e]; a noble piece of masonry it was. The principal new f[eat]ure in this structure was the elliptical arch, which Myline was the first to introduce into England.

When the numerous heavy piers of old London Bridge, which acted as a dam across the river—had been remo[ved] the low-water mark above the bridge fell 5 ft. The velocity of the unimpeded tide, sweeping up and down Thames twice in every 24 hours, and the consequ[ent] increased scour along the bed of the river, soon beg[an] grind away the foundations both of Blackfriars and W[est]minster bridges; and they exhibited the unsightly a[p]pearance of numerous props and centerings to prevent f[ur]ther subsidence of their foundations. Hence Labely[e's] bridge at Westminster, and Myine's at Blackfriars, ha[ve] since been pulled down to make room for newer bridg[es].

Yours truly, G. E. M.

New London, Conn., July 1, 1902.

(In view of the apparent lack of definite information respecting this famous structure, some further description of its history and construction may be of interest. In London "Engineering" of March 8, 1895, there was published a description of the Westminster Bridge which formed one of a series of very interesting articles which appeared in that journal under the general title of "Thames Bridges." These articles were evidently based on a very considerable amount of original research and the facts given are probably reasonably authoritative. We quote as follows:

> The predecessor of the late Mr. Thos. Page's handsome bridge at Westminster was completed in 1750, and replaced a landing stage and ferry. . . . The history of old Westminster Bridge, no less than its engineering features, is very full of interest. The Act of Parliament sanctioning its construction was passed in 1736, and was supplemented by a second Act in 1738, determining the site. The original proposal was for a wooden structure with stone piers, and a design for this was submitted and approved; it was, however, set aside in favor of a stone bridge by Charles Labelye, a naturalized Swiss and an engineer of considerable repute in his generation. His design was finally approved in 1738, the same year that the site was fixed upon. . . . . It consisted of 15 semicircular arches, the central one being 76 ft. span, while the others on each side decreased by successive amounts of 4 ft. to the end or land arches, which were only 25 ft. span. The total length of the bridge was 1,220 ft., and the waterway 870 ft. The piers were all 70 ft. in length from point to point of the cutwater, and the width of the two at the middle of the bridge was 17 ft., the others decreased successively in width by 1 ft., so that the last pair on each side were 12 ft. wide; the springing of the arches was 2 ft. above low-water level, and the width of the piers at the foundations was 4 ft. greater than at the top. . . . Old Westminster Bridge was 44 ft. wide up to the roadway level, and the parapet walls were built on a projecting cornice; the roadway was 30 ft. in width, and over each pier shelter recesses were provided. . . . It was opened on November 10, 1750. . . . remained in good condition until 1810, when extensive repairs were found necessary; between that year and 1838 no less than £83,097 were spent on maintenance, and during the next five years nearly as much more. The chief cause of decay was the failure of the foundations.
>
> The new bridge was designed by Thos. Page, who prepared designs for three and five arches. The final design, for seven arches, was prepared in collaboration with Sir Charles Barry, so far as the architectural features were concerned. . . .
>
> The bridge is composed of seven main arches and two small arches on the Surrey shore; the spans decrease from 120 ft. in the center to 94 ft. 9 ins. The piers are of granite, . . . the abutments, as well as the small arches on the Surrey side, are of brick faced with stone taken from the old bridge and reworked. The superstructure consists of a combination of cast and wrought-iron ribs, the former serving practically as brackets extending from the piers to support the wrought-iron girders that complete the arches of each span. The roadway is carried on these ribs, which are placed 5 ft. apart under the road, and 7 ft. apart under the sidewalks; the central or wrought-iron portion of the ribs is in the larger spans 52 ft. long and of 28 ins. minimum depth, in the land spans 42 ft. 3 ins. long and 22 ins. minimum depth. There are 15 ribs carrying the platform across each span. . . . The roadway is about 52 ft. wide and the sidewalks are each 15 ft. in width.

In the same issue of "Engineering" there is shown a large plate-halftone of the present Westminster Bridge, and a sketch cut of the old bridge. It may be noted further that the article gives the following references on the two Westminster bridges. For the old bridge, cf. Walmisley's "Thames Bridges" and Cressy's "Encyclopædia of Civil Engineering"; for the new bridge, see Humber's "Book on Bridges" (1861). It seems, then, that the note of Mr. Luten is practically correct, but that the reference is to the old bridge, which has not existed for the last fifty years. On the other hand, our London correspondent J. W. S. is correct, but speaks of the new, or present, bridge. It may be remarked as interesting that J. W. S. quotes the very article from which we abstracted the preceding, in support of his criticism of Mr Luten, while that same article is most explicit in its remarks on the old bridge.—Ed.)

AN INVESTIGATION OF ELECTRIC OPERATION OF TRAFFIC ON THE MOTT HAVEN DIVISION, NEW YORK CENTRAL & HUDSON RIVER R. R.*

By Bion J. Arnold,†

In August, 1901, the writer was commissioned by the New York Central & Hudson River R. R. to study the conditions governing the operation of its trains between Mott Haven Junction and Grand Central Station, and to report upon the feasibility of operating them by electricity. This division consists of 5.3 miles of four-track road forming the trunk line or main artery over which the trains from two divisions of the New York Central and from the main line of the New York, New Haven & Hartford R. R., enter the City of New York. For 2.58 miles from Mott Haven Junction the tracks are carried on an elevated stone and steel structure; then for 2.04 miles through a tunnel underneath the street, emerging into an open cut .68 of a mile long, then terminating at the Grand Central Station in an intricate sub-end yard, having about eight miles of switching tracks. Over this division nearly 600 train movements per day are made, because almost all trains entering the yard or station must be returned to Mott Haven Junction, owing to lack of sufficient storage tracks at the Grand Central terminus.

The annoyance to passengers due to the use of steam locomotives in the tunnel caused the company to examine into the advisability of adopting electricity, and it is through the courtesy of Mr. W. J. Wilgus, Chief Engineer of the company under whose directions the investigation was made, that the writer is allowed to make public the technical substance of this report.

All money values relating to total cost of installation, real estate, etc., any many other elements upon which the final recommendations of the report were based, together with many of the general recommendations and conclusions themselves, are necessarily omitted from this paper, but it is believed that the data given are sufficiently complete to enable one to check the technical conclusions herein given.

Soon after taking up the work it became evident, on account of the number and weights of the trains to be handled and the numerous variable elements entering into the operating system, which would not adapt themselves conveniently to formulas, that the most practical and satisfactory way of ascertaining the power required to propel the trains was to measure, by means of a dynamometer car, the drawbar pull of a sufficient number of trains of various weights, to determine the average power required per train and from this to compute the general load diagram.

A dynamometer car, owned jointly by the Illinois Central Ry. Co. and the University of Illinois, was secured, and men thoroughly skilled in its use were employed to operate it.‡

This car contains apparatus which measures and records various data relating to the speed of the car and the pull or the pressure on its drawbar, as will be seen from the sample diagrams reproduced herewith. It was coupled between the engine and the train in each case, and operated on trains running over the different divisions of the road, so that not less than four runs, two or more in each direction, were made for each class of train.

Since the trains of all divisions, including those of the New York, New Haven & Hartford R. R., run over the New York Central tracks between Mott Haven Junction and the Grand Central Station, the records of the New York Central trains for this section of line will apply to trains of equal weight on the New York, New Haven & Hartford road, and were so considered in the calculations.

In the accompanying drawings, Figs. 1, 2 and 3, are reproduced representative records obtained by means of this car. A large number of such records were obtained, for trains varying in weight from very light suburban trains to heavy through express trains. Each record shows the following separate data:

(1) The drawbar pull of the train at any instant, as recorded by the pen of the dynamometer. The horizontal scale, which is the same for all lines on the diagram, represents distance, the motion of the record paper being obtained by gearing from the car-axle. The vertical ordinates represent drawbar pull in pounds, to a known scale (noted for our reductions* on the records reproduced.—Ed.)

(2) The speed of the train, by a Boyer speed recorder; the vertical scale for speeds is noted on the diagrams.

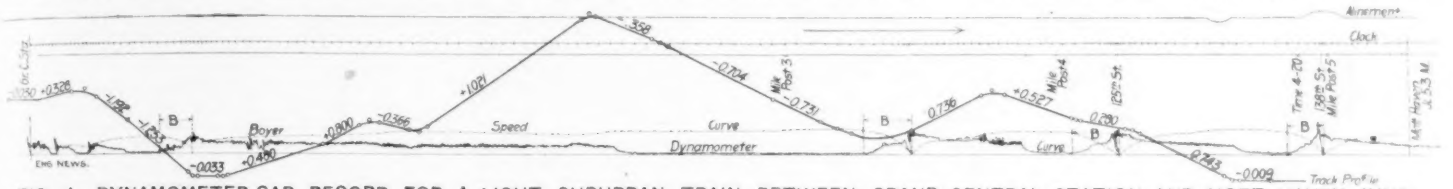


FIG. 1. DYNAMOMETER-CAR RECORD FOR A LIGHT SUBURBAN TRAIN BETWEEN GRAND CENTRAL STATION AND MOTT HAVEN JUNCTION, NEW YORK CENTRAL & HUDSON RIVER R. R.

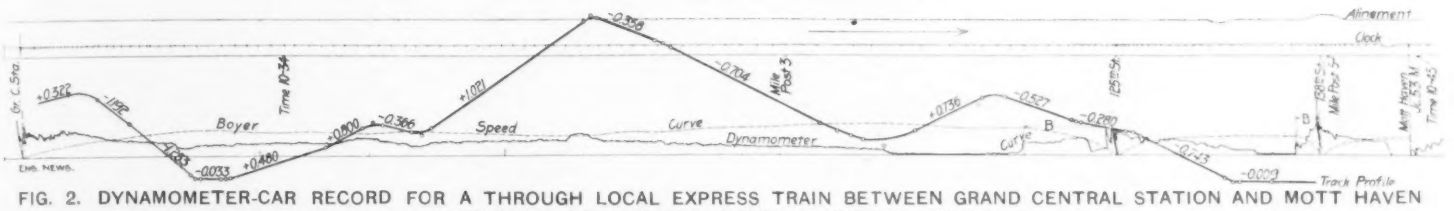


FIG. 2. DYNAMOMETER-CAR RECORD FOR A THROUGH LOCAL EXPRESS TRAIN BETWEEN GRAND CENTRAL STATION AND MOTT HAVEN JUNCTION, NEW YORK CENTRAL & HUDSON RIVER R. R.

Horizontal Scale, Distance: 1 mile to 1.59 inch. Vertical Scale, Speed: 0.225 inch equals 60 miles per hour. Vertical Scale, Drawbar Pull: 1 inch equals 89,200 lbs.

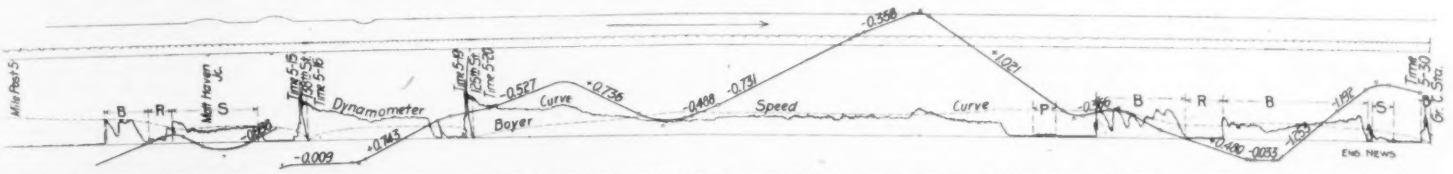


FIG. 3. DYNAMOMETER-CAR RECORD FOR A VERY HEAVY THROUGH EXPRESS TRAIN BETWEEN MOTT HAVEN JUNCTION AND GRAND CENTRAL STATION, NEW YORK CENTRAL & HUDSON RIVER R. R.

Horizontal Scale, Distance: 1 mile to 1.403 inch. Vertical Scale, Speed: 0.199 inch equals 60 miles per hour. Vertical Scale, Drawbar Pull: 1 inch equals 78,900 lbs.

(3) The profile and the alinement of the track, drawn on the record from data supplied by the engineering department of the road.

(4) A check time-record, given by a clock marking every 5 seconds.

(5) A position record, consisting of marks produced by a pen when an electric button is pressed, and used to record stations and mileposts passed, etc.

It should be noted that the records do not include the power required to propel the locomotive nor the head-end resistance offered to it by the air, and that when the dynamometer car was running backward, the power to propel it is not represented in the record and its weight should not be taken into consideration as a part of the train. These factors were taken into account when determining the final load diagram.

The records here reproduced represent the following: Fig. 1.—A light suburban train on the Harlem Division, running between Grand Central Station and Lake Mahopac; test car running forward. The train consisted of the test car, weighing 44,650 lbs., two coaches and one combination car, weighing together 211,200 lbs.; live load about 9.4 tons; total weight of train behind engine, 137.3 tons. Hauled by N. Y. C. engine No. 987, with 65,500 lbs. weight on drivers; total weight loaded, engine and tender, 169,200 lbs. Fig. 2.—A through local express train on the Hudson Division, between New York and Schenectady; test car running backward. The train consisted of one express car, five coaches and one Pullman chair car, total weight, 296.7 tons or with passengers 311.5 tons. Hauled by N. Y. C. engine No. 936, with 90,000 lbs. on drivers; total weight of loaded engine and tender, 228,200 lbs. Fig. 3.—A very heavy through express train on the Hudson Division, running between Chicago and New York; test car running backward. Train consisted of three baggage cars, two express cars, two mail cars, three coaches, and three Pullman sleepers, with a total weight of 434.5 tons, or with live load 456.2 tons. Hauled by N. Y. C. engine No. 2,013, with 134,300 lbs. on drivers; total weight of loaded engine and tender, 287,000 lbs.

The letter B on the records indicates the time when brakes were applied, and the letter R when they were released. The letter S denotes the time when the engine was under steam; this symbol is shown at only one or two points, to aid in understanding the records. The letter P shows when the dynamometer was pumped full of oil (leakage past the piston and stuffing boxes having brought the piston near its limit of travel); the roughness of the drawbar pull curve is due to the impulses of the oil pump.

The severe oscillation of the dynamometer pen on some of the records exhibits the irregular turning moment of the engine which is caused partly by unequal distribution of the steam in the cylinders, due to the lack of proper adjustment of the valve motion, and partly to the irregular turning moment of any two-cylinder engine of this type.

It appears from the records that the braking effort per ton is not as high on certain types of locomotives as it is on coaches. This is due to the fact that not all the wheels of the locomotive are always braked, and those that are braked cannot be set to the skidding point with a fully loaded tender, for if they were they would then skid with a lightly loaded tender. Hence the drawbar pull during retardation is often as great, or even greater than it is during acceleration. Instances of this may be noted in the sample records reproduced.

The questions of changes in the Grand Central terminal or in the present method of train operation, or of handling the suburban trains on the division outside of Mott Haven Junction are not considered in this paper. The problem submitted was to duplicate the present passenger train service between Mott Haven Junction and Grand Central Station by using electric power instead of steam locomotives. In other words, an electric system had to be provided capable of supplying at any instant the aggregate amount of power required for the operation of the division. The dynamometer records just referred to were used in determining this power. The separate intermediate steps in this were: (1) To determine from speed and drawbar pull the horse-power required to pull the various trains at their schedule speeds, and, (2) to obtain the aggregate power required on the division at any moment by summing the items of power for the different trains then running on the division. When thus the amount of power required was known for every instant of the day, the daily average of power could be found, and all further calculations entered upon as to the plant necessary, cost of operation, etc.

In calculating the power required to operate any one train, allowance was made for the increased train weight due to motor equipment (since the dynamometer records were in each case taken behind the locomotive and therefore did not include the drawbar pull required for the

*A paper presented at the annual convention of the American Institute of Electrical Engineers, held at Great Barrington, Mass., June 19-21, 1902.

†Consulting Electrical Engineer, Marquette Bldg., Chicago.

‡For a full description of this car and the apparatus it contains, see Engineering News of Aug. 2, 1900; further notes on the car with some results obtained by it are given in Engineering News of July 11, 1901.

*It may be noted that the original records are about ten times the size of our reproductions. The original scales were: Horizontal, 13.2 ins. to 1 mile; vertical, 1-32-in. equals 1 mile per hour, and 7,428 lbs. drawbar pull equals 1 in.

att'd). Owing to the fact that the maximum speeds on this division seldom exceed 35 miles per hour and that the trains were never less than three cars in length—often reaching eleven cars in length—no correction was made for head-end air resistance.

The successive steps in these calculations of power were as follows:

(1) In order to determine the average drawbar pull for any given period, the entire area under the dynamometer pen record was found by a planimeter and divided by the length of base of the interval from start to stop, the result being the average drawbar pull.

(2) From passenger records taken during dynamometer tests, the curve shown in Fig. 4 was plotted, showing the

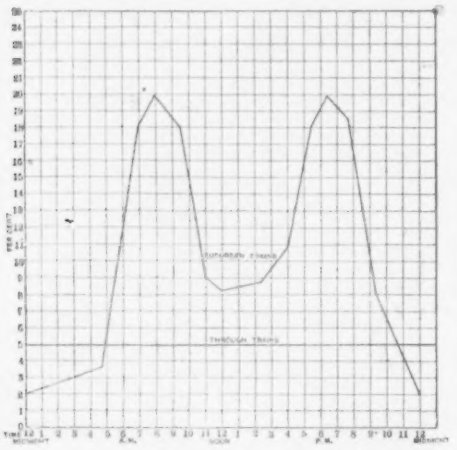


Fig. 4. Curves Showing Ratio of Live Load (passengers, baggage, express etc.), to Dead Weight of Train, in per cent.; for Trains Operating over Mott Haven Division, New York Central & Hudson River R. R.

ratio of the weight of the live load to the light weight of the train.

(3) Dividing the average pull in pounds by the total weight of the train, the average drawbar pull in pounds per ton, over the run under consideration, was obtained. The average drawbar pull thus obtained for each run is shown in Table I. (not reproduced.—Ed.). The means of the values set forth in Table I. are shown in Table II.

The average drawbar pull (not tractive effort) in pounds per ton, for various lengths of run over the Mott Haven Division are shown in Curve 1, of Fig. 5. Curves 2 and 3 show these values for longer runs, as obtained on the Harlem and Hudson divisions respectively, and Curve 4, which is the mean of Curves 1, 2 and 3, shows very roughly what may be expected to obtain as the average value of the drawbar pull under ordinary steam railroad conditions, on a level and comparatively straight track, with various weights and length of train (three to ten cars, 100 to 400 tons), and at an average speed of about 30 miles per hour. The question of grade is here eliminated for each point shown represents the average value of two runs on the same train, one north, the other south. The number of variables entering into these values such, for example, as the degree of skill of the engineer, the wind velocity, the condition of the track, agreement with schedule time, etc., make it impossible for any curve to pass through all its points and therefore, as above stated, these curves can only be taken as indicating the average value of a widely varying quantity.

(4) By means of a simple graphical diagram, the average speed between any two stations was found from the known time of run between these stations.

(5) The weight of every train arriving or leaving the Grand Central Station on a given day was obtained, and its average speed between stops determined from the above diagram. Knowing, therefore, the average drawbar pull in pounds required to haul a train, and the average speed at which this drawbar pull was exerted, the horse-power at the drawbar becomes:

$$\text{HP.} = \frac{\text{foot-pounds per minute}}{33{,}000};$$

$$\text{HP.} = \frac{\text{drawbar pull} \times \text{miles per hour} \times 5{,}280}{33{,}000 \times 60};$$

$$\text{HP.} = \frac{\text{drawbar pull} \times \text{miles per hour}}{375}.$$

A graphical diagram was used for this calculation, and the same diagram permitted the horse-power to be transformed into kilowatts and this value further increased to allow for an assumed efficiency in the motors of 70%.

These calculations were made for a full day of 24 hours, Oct. 23, 1901, and were summarized in Table III. (not reproduced here.—Ed.). This table showed for each train, for each separate run between stops, the average horse-power required during that run. The table was used in drawing up the total power required on the Mott Haven Division at any moment during the day. The method used in preparing the diagram was a graphical one, and is illustrated in Fig. 6. Here horizontal distances indicate time, in the portion shown in the figure the half-hour from 6 a. m. to 6:30 a. m., Oct. 23, 1901. At the bottom of the diagram is seen a set of horizontal lines marked with the names of the stations; these lines are spaced to represent in vertical interval the distances between the stations. The oblique lines running between these represent the course of trains, in time and distance. Now, from Table III. is taken the average horse-power required by any one train in its run between stops. Thus, the third train shown in Fig. 6 to start from Grand Central Station after 6 a. m., a New York, New Haven & Hartford train, does not stop before Mott Haven Junction, and is shown by Table III. to require an average of 155 HP. on this run. This amount is laid off vertically to scale, from a baseline of zero horse-power, as will be seen by dotted line in the figure.

TABLE II.—Showing Average Drawbar Pull in Pounds per Ton and Horse-power Required to Propel Electric Locomotives for Different Runs.

Terminal stations of run.	Going out. Drawbar pull, per ton.	Going out. Locomotive HP.	Coming in. Drawbar pull, per ton.	Coming in. Locomotive HP.
Bet. G.C.Station and 110th St.	17.0 lbs.	75 HP.	12.80 lbs.	71 HP.
125th "	16.13 "	88 "	12.10 "	65 "
138th "	12.00 "	.. "	..... "	.. "
Mott H. Junct'n.	14.80 "	76 "	12.72 "	56 "
Bet. 110th St. and 125th St.	22.46 "	95 "	24.00 "	98 "
138th "	..... "	.. "	..... "	.. "
Mott H. Junct'n	"	.. "	13.10 "	.. "
Bet. 125th St. and 138th St.	18.10 "	51 "	22.70 "	55 "
Mott H. Junct'n.	16.00 "	73 "	17.00 "	58 "
Bet. 138th St. and Mott H. Junct'n.	25.00 "	62 "	14.80 "	65 "

Note.—Figures given under "Locomotive HP." represent the average horse-power required to propel a 65-ton electric locomotive over that run, plus 1 HP. for pumps.

The same procedure is carried through for each train, giving a mass of superimposed power-time diagrams, as is seen in the portion of the diagram shown in Fig. 6. These areas are now added for the intervals of time which they cover, and the total horse-power reduced at the same time to kilowatts. In this way is obtained the heavy irregular line which will be seen near the top of Fig. 6, marked "Curve 1." This curve is shown for a period of six hours, from 6 a. m. to 12 m. of Oct. 23, 1901, in Fig. 7. It illustrates the variations in the demand for power on the whole Mott Haven Division, by the operation of regular line trains.

This diagram was drawn for the full 24 hours of the day referred to. The area under Curve 1 was averaged for the day, and assuming the demand for power equalized throughout that period, Curve 4, Fig. 7, was obtained. (This curve, as well as Curve 1, also contains the power required to propel the electric locomotive to be used.

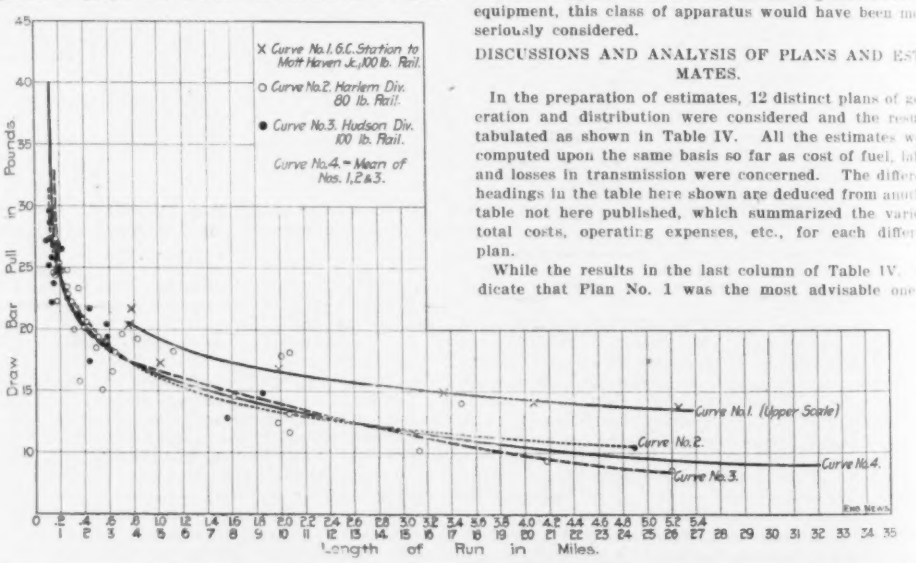

X Curve No.1. G.C. Station to Mott Haven Jc., 100 lb. Rail.
○ Curve No.2. Harlem Div. 80 lb. Rail.
● Curve No.3. Hudson Div. 100 lb. Rail.
Curve No.4. = Mean of Nos. 1, 2 & 3.
Pounds in Pull Bar Draw
Curve No.1. (Upper Scale)
Curve No.2.
Curve No.3.
Curve No.4.
Length of Run in Miles.

FIG. 5. CURVES SHOWING AVERAGE VALUES OF DRAWBAR PULL IN POUNDS PER TON FOR DIFFERENT LENGTHS OF RUN BETWEEN STOPS.

For Trains from 100 to 400 Tons, at an average speed of about 30 miles per hour, on straight, level track, Under Average Steam-Railroad Conditions.

From a careful examination of the weights of all locomotives in service on this division, it was found that properly powered electric locomotives having a total weight of 65 tons each, all of which would be available for tractive effort, could satisfactorily perform the service of existing steam locomotives. To each separate train-power curve, therefore, as plotted in Fig. 7, is added the power required to propel a 65-ton locomotive.)

These curves show power required for regular trains, or line service, only, and to get total power it is necessary to add that required for switching and shop-train service. The latter were found to represent hourly demands as shown in Curves 3 and 4, Fig. 8, where Curve [illegible] the hourly averages of power required for line [illegible] The mean values of Curves 3 and 4, Fig. 8, appear [illegible] as Curves 5 and 6 Fig. 7.

The sum of Curves 4, 5 and 6, in Fig. 7, [illegible] Curve 7, Fig. 7, which therefore represents [illegible] daily kilowatt input required at contact shoes [illegible] tives for all service. Similarly, Curve 1, Fig. [illegible] sum of Curves 2, 3 and 4 in the same figure, [illegible] condensed load diagram of the entire service, [illegible] hourly variations.

From Curve 7, Fig. 7, it is seen that the daily [illegible] input required would be at the rate of 1,800-K. [illegible] therefore, the total annual input required at the [illegible] shoes of the locomotives, for propulsion alone, [illegible] 15,768,000-K-W. hours. From the total number [illegible] nualed yearly over this division, including passenger [illegible] trains and switching service, the ton-miles per year [illegible] found to be 250,285,710. Hence, the electrical energy [illegible] quired to haul a ton-1 mile over this division under [illegible] existing conditions would be 63 watt-hours per ton mile.

With this figure as a basis and the load factor as determined from the load diagram, the problem of determining the best method of producing, distributing and [illegible] the power was considered.

CHOICE OF SYSTEM.

While it is the writer's opinion that the alternating-current railway motor will yet prove to be the most efficient, all things considered, for long distance railway work, it has not yet in his opinion demonstrated its ability to start under load as efficiently or to accelerate a train as rapidly as the direct-current motor. The line under immediate consideration was short, the trains numerous and rapid acceleration desirable, all of which are conditions favorable to the direct-current motor.

Furthermore, direct-current motors with their necessary auxiliaries have become fairly well standardized and it is the only class of electric railway apparatus available from the manufacturers of the United States without involving experimental work and large development expense.

In view of these facts and the probable necessity for rapid construction, the writer refrained from advising anything of an experimental nature and, therefore, recommended the direct-current system in combination with the third-rail for the main line, and overhead construction for the yards, all of which have demonstrated fully their ability to meet the conditions imposed by railway operation so far as motive power is concerned, although there has not yet been an electric installation on any existing terminal that is as complex, or into which anywhere near the number of heavy trains enter as on this section of road.

Had the length of road under consideration been considerably greater, and had it been thought possible to secure sufficient time to conduct experiments or invite demonstrations by manufacturers of alternating current motor equipment, this class of apparatus would have been more seriously considered.

DISCUSSIONS AND ANALYSIS OF PLANS AND ESTIMATES.

In the preparation of estimates, 12 distinct plans of generation and distribution were considered and the results tabulated as shown in Table IV. All the estimates were computed upon the same basis so far as cost of fuel, labor and losses in transmission were concerned. The different headings in the table here shown are deduced from another table not here published, which summarized the various total costs, operating expenses, etc., for each different plan.

While the results in the last column of Table IV. indicate that Plan No. 1 was the most advisable one to adopt, it was not seriously considered for the reason that it necessitated locating the power station in a part of the city where its erection would probably have been prohibited by the city authorities, but it was here introduced for comparison as indicative of the economy to be gained by placing the power station at the theoretical center of distribution. The same objections apply to Plans 2 and 3. Plans 4 and 5 bring out quite clearly the difference in the cost of operation between two substations and one, both plans permitting the location of the power station on the river front. The difference in favor of Plan 5 is entirely due to the saving in labor of one substation.

TABLE IV.—Table of Estimates on Plans for Proposed Electrical Equipment of the N.Y.C. & H.R.R.R., Between Grand Central Station and Mott Haven Junction.

Reference No.	Character of stations, etc., in the different plans.	Operating expenses per K-W.-hr. At power-house switchboard. cts.	Operating expenses per K-W.-hr. At contact shoe. cts.	Total cost per K-W.-hr. delivered to motor terminals, exclusive of fixed and operating charges on electric locomotives. cts.	Total operating expense per locomotive mile exclusive fixed charges. cts.	Fixed charges per electric locomotive-mile. cts.	Total charges (operat'g + fixed) per electric locomotive-mile cts.
1	Direct-current power station at center of line and contiguous to tracks. 600-volt working conductor; no batteries.	0.447	0.60	1.06	14.02	6.58	20.60
2	Same as No. 1, with batteries in power house.	.472	.66	1.137	14.65	6.71	21.36
3	Same as No. 1, with battery substation near Grand Central Station and Mott Haven Junction.	.475	.668	1.20	14.7	7.25	21.95
4	Alternating current power station on river front near center of line, with rotary converter substation near each end of line. 11,000-volt A. C. and 600-volt D. C.	.572	.715	1.287	15.2	7.58	22.78
5	Combined D. C. and A. C. power station at Harlem River near one end of line and one rotary converter substation near the other end of line. 11,000-volt A. C., 600-volt D. C., no batteries.	.570	.666	1.19	14.7	7.18	21.88
6	Direct-current feeders from Manhattan Ry. substation located near center of line. Transmission from substation to working conductor. 600-volt D. C. energy to be purchased	2.5	2.650	2.748	34.64	2.89	37.53
7	Rotary converter substation at center of line. A. C. energy to be purchased from Manhattan substation and transmitted at 11,000 volts. Energy to cost ½-ct. less per K-W. hour than D. C. energy delivered	2.5	2.336	2.508	31.50	4.23	35.73
8	Two rotary converter substations, one near each end of line. A. C. current to be purchased from Manhattan substation near center of line	2.1	2.336	2.504	31.50	3.93	35.43
9	Combined A. C. and D. C. power station near Harlem River at end of line. One substation near other end, and batteries carried on locomotives charged from working conductor	.519	.629	1.122	16.58	7.76	24.34
10	One rotary converter substation near center of line, A. C. current purchased from Manhattan substation No. 7, batteries on locomotives charged from working conductor	2.12	2.4	2.502	34.40	4.08	38.48
11	Direct current feeders from Manhattan substation No. 7, near center of line. Batteries on locomotives charged from working conductors.	2.5	2.738	2.742	37.81	2.51	40.32
12	Combined A. C. and D. C. power station at Harlem River near outer end of line. One substation near other end. Batteries in power station and substation. A. C. transmission 11,000 volts, D. C. conductors 600 volts.	.55	.775	1.335	15.80	7.83	23.63

Plans 6, 7 and 8 were studied with the object of ascertaining whether the purchase, instead of the generating of power, would offer a satisfactory solution of the problem. The purchase of both D. C. and A. C. energy was considered on the lowest basis that it was thought possible for any existing company to furnish it, and it was found that the D. C. energy would cost the railroad company ½-ct. more per K-W.-hour than the A. C. energy, in consequence of the interest, depreciation, maintenance, etc., of the transmission lines, rotary converters and other substation apparatus which would have to be furnished by the energy producing company. The prohibitive annual cost of these purchasing plans is at once observed by reference to the second and last columns of figures, the plans only meriting consideration as representing a temporary arrangement that might be effected in order to allow rapid installation.

Owing to the more or less complex system of overhead or third-rail yard construction made necessary by the nature of the case, and the advantages to be obtained by their elimination in the substitution of locomotives which could, for switching service, be self-contained, though normally supplied with energy from the working conductors, a study was made of electric locomotives carrying batteries. The results of these studies made under different assumptions are shown under Plans 9, 10 and 11. From the third and last columns of figures it is evident that whatever may be gained by the elimination of the overhead construction is largely offset by the additional cost of operation, although it will be observed that the cost per locomotive-mile of Plan 9 compares favorably with the cost of Plan 12.

Plan 12 differed only from Plan 5 in a slight reduction in the capacity of the converting apparatus in the power-house and substations, and the substitution therefor of two storage batteries (one located in or near the power-house and one in the substation) each of such capacity that it, together with only a portion of the main station and substation machinery, would be capable of taking over the entire load of the line for a short period of time in cases of emergency. The additional first cost and the slight increase in annual expense (as compared with Plan 5) represented by a reserve station capacity of this nature was thought to be of secondary importance only, in view of the increased reliability of operation thereby obtained. The increased cost of operation in this plan over that of Plan 5 is due to the fact that the battery maintenance was figured at 10% per annum, which is considerably higher than is ordinarily assumed, and will probably be considered excessive by some. A battery of this kind would not only serve as a reserve but would prove of considerable value as a regulator of potential along the line, and in addition it would, notwithstanding its inherent losses, tend to reduce the power house operating costs by taking up the excessive load fluctuations of the system and permitting the load upon the engines to be maintained at or near their most efficient working capacity.

It was considered of the utmost importance in an installation of this magnitude that the number of interruptions of power supply be reduced to a minimum, that no device which could increase the safety and reliability of the plant should be omitted, and that the probability of future extensions of the electrical system should be considered. As best fulfilling the above conditions, therefore, Plan 12 was the one specifically recommended for adoption.

OPERATING EXPENSES.

A careful compilation of all the expenses entering into the operation of the present steam service was made and the following comparative table (Table V.) of relative costs is believed to be correct, assuming that the present locomotives running between Mott Haven Junction and Grand Central Station should be abandoned and the service now performed by them duplicated by electric locomotives operated in accordance with Plan 12. It is assumed that the electric locomotives will be operated by the same class of men as those who now operate the steam locomotives and that they would receive the same rate of pay that they now receive.

This condition is not favorable to electric traction as it is not ordinarily necessary to have the two men to operate an electric motor, but in the writer's judgment, it is not advisable to operate a service of this class under such exacting conditions without two men on each locomotive.

If the motor-car system should be adopted, as it probably would be were the electrical equipment extended beyond Mott Haven Junction, or if the forward guard or brakeman were allowed to take the place of the second man while passing through the tunnel and yards, a saving equivalent to his wages could thereby be effected. With two men of the same skill as at present employed on the locomotives, the figures are as follows:

TABLE V.

	Steam.	Electricity.
Operating expenses per locomotive-mile exclusive of fixed charges, but including water, labor, cost of cleaning and repairing tunnel, and all other expenses of locomotive operation, cts.	23.05	15.80
Fixed charges per locomotive-mile assuming that it now requires 40 locomotives to perform the present service and that 33 electric locomotives could perform the same service, cts.	1.13	7.83
Total, cts.	24.18	23.63

From these figures it appears that while there would be slight annual saving in operating expenses in favor of electricity, it is not sufficient to warrant its adoption on the grounds of economy in operation alone, although its adoption can be justified on other grounds.

These figures could be made more favorable to electricity were an optimistic view of many of its advantages taken, and the probability is that practical operation will show a somewhat greater gain than here indicated, but it has been deemed best by the writer to maintain a conservative view throughout the entire investigation.

It is, however, safe to conclude that the saving in operation expenses by the electric system would be sufficient to offset the increased fixed charges due to the additional investment made necessary by its adoption.

DEATH AND INJURY FROM ELECTRIC SHOCKS.

At the meeting of the Institution of Electrical Engineers (England) on Feb. 27, the general subject for discussion was "Electric Shocks." One of the papers dealing with this subject presented much information on fatal and nearly-fatal cases of electric shock, and on some physiological phenomena attending the shocks. The information was apparently carefully gathered and refers to

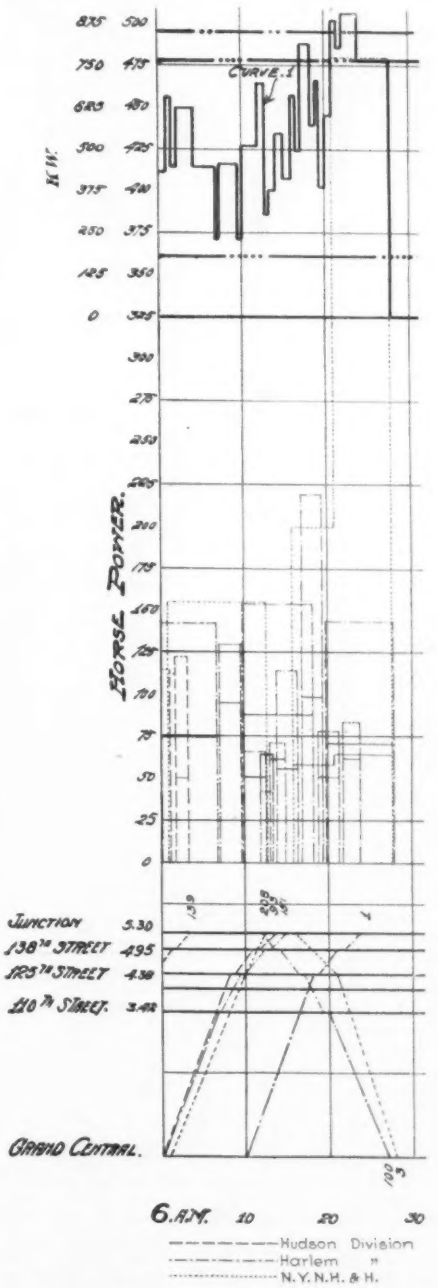


Fig. 6. Graphical Method of Obtaining Load Curve.

actual cases occurring in commercial electric working. Another paper considers more particularly shocks from 500-volt direct-current circuits, and brings out the, in general, harmless character of such circuits. So little information is available on these matters that we abstract from the London "Electrician" the two papers referred to:

ELECTRIC SHOCKS.

By F. P. Aspinall.

I have been deeply interested in this subject for some years and have collected, from my own experience and that of friends, particulars of as many cases as possible. I have also, whenever I could, made it a rule to see the man who received the shock, and also any witnesses. All

cases, therefore, which I have chosen as of sufficient importance to mention in this paper are, to the best of my belief, thoroughly accurate and reliable. In obtaining this information I have been much struck by the fact that it is most difficult to obtain a really accurate description from the victim or witnesses of what actually does occur, and this can hardly be expected when one considers the circumstances; still, as I only mention what they are absolutely certain about, these cases can be taken as fairly typical.

(1) IS EVERYONE EQUALLY SUSCEPTIBLE TO ELECTRIC SHOCKS?—I believe I am stating the opinion of the medical profession when I say that there is no reliable proof whether everyone is equally susceptible or not. My opinion is that not only are different people differently affected, but the same person under different conditions does not feel the same. When it is considered that moistness, callosity and condition of skin, nervous temperament, the path which the current takes through

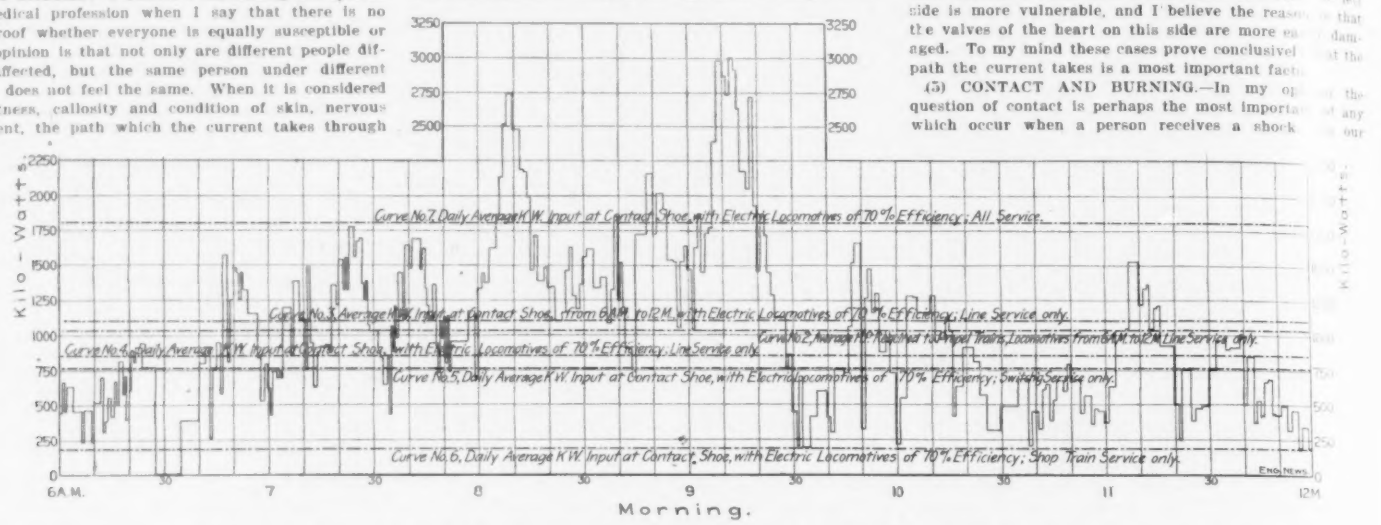

Curve No. 7, Daily Average K.W. Input at Contact Shoe, with Electric Locomotives of 70% Efficiency; All Service.
Curve No. 3, Average K.W. Input at Contact Shoe, from 6 A.M. to 12 M., with Electric Locomotives of 70% Efficiency; Line Service only.
Curve No. 2, Average K.W. Input at Contact Shoe, with Passenger Trains, Locomotives from 6 A.M. to 12 M. Line Service only.
Curve No. 4, Daily Average K.W. Input at Contact Shoe, with Electric Locomotives of 70% Efficiency, Line Service only.
Curve No. 5, Daily Average K.W. Input at Contact Shoe, with Electric Locomotives of 70% Efficiency; Switching Service only.
Curve No. 6, Daily Average K.W. Input at Contact Shoe, with Electric Locomotives of 70% Efficiency; Shop Train Service only.
Kilo-Watts.
6 A.M.
12 M.
Morning.
ENG. NEWS.

FIG. 7. LOAD CURVE FOR MOTT HAVEN DIVISION FROM 6 A. M. TO 12 M., OCT. 23, 1901.

however, to state that his hands were exceptionally callous, due to the fact that he had been working as a gas stoker, and also that his hands were severely burnt. Personally, however, I think the man received quite enough to kill him, and his being drunk had something to do with his not being killed. Next, are persons less liable to be killed when they are asleep? Some years ago I was carrying out a contract which necessitated all the work being done at night. One of the men employed was always going to sleep, so the other men, as a practical joke, gave him a shock whilst he was in this condition from a magneto machine capable of ringing through 30,000 ohms, but although they tried all they could he did not wake. As they thought this was peculiar the men called my attention to it, and I personally saw him receive a shock without taking any notice of it. I may also say that I arranged for my assistant to give me a shock when I was in bed asleep, and although two witnesses guaranteed he had done so, I felt nothing. Illustrating this, I should like to mention the following case: "B" was stationed to watch a cable under test charged to 5,000 volts, and going to sleep fell on to it. He was most severely burnt about hands, but was not killed.

(4) PATH OF THE CURRENT.—Amongst all electrical engineers I know it is a firm belief that the path which the current takes is of the utmost importance, and therefore in handling high-tension apparatus we always try not to make contact in such a way that a vital part is directly in the circuit. To illustrate the effects of different paths the current can take I give the following: Hand to hand, blow in chest; right hand to right foot, nothing; right hand to left foot, nothing; right hand to both feet, nothing; left hand to left foot, blow in back of neck; left hand to right foot, blow in back; left hand to head, blow on top of head; head to buttocks, could not ascertain if anything was felt.

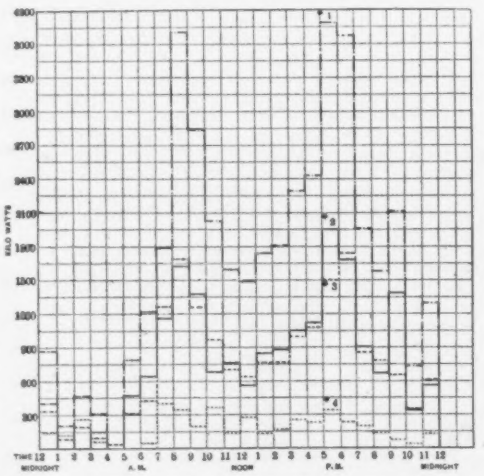


Fig. 8. Hourly Load Diagram, Mott Haven Division, Oct. 23, 1901.

Of course, I cannot say why they should feel differently, but I think it proves that different organs of the body are affected. Dealing with this from actual cases: "D" was oiling an alternator, and touched the inner brush accidentally with his elbow; his right foot was on the earthed frame of machine, and his left foot insulated. The pressure was 2,200 volts, and although he gave a cry, and was sensible till the circuit was broken, he could not get away. He remembered them running to shut the machine down, but became insensible when this was done, and [illegible] treated for 40 minutes by artificial respiration [illegible] showed any signs of life. One would have ex[illegible] this man to be killed, but it is only fair to say [illegible] was badly burnt on the elbow and the foot. "J" was [illegible] adjusting an arc lamp. He had his left foot earthed [illegible] with his left hand touched the carbons. I am unable [illegible] state the number of volts that he received, as I could [illegible] not ascertain where the current earthed; but he was killed. There was only a slight discoloration noticeable [illegible] and he was not burnt. I will discuss the question [illegible] burning later on, but I think it is a fair conclusion that [illegible] left side is more vulnerable, and I believe the reason [illegible] that the valves of the heart on this side are more easily damaged. To my mind these cases prove conclusively [illegible] at the path the current takes is a most important fact.

(5) CONTACT AND BURNING.—In my opinion [illegible] the question of contact is perhaps the most important [illegible] of any which occur when a person receives a shock [illegible] our ordinary every-day work perhaps the question of contact receives more attention than anything else; when a man receives a shock this question should be of equal importance. To illustrates what an important part the area of contact plays, I had my resistance measured holding a No. 20 B. W. G. copper wire between the finger and thumb of each hand and afterwards I connected these two wires to two pennies and held them in the same way. With the pennies my resistance was 20,000 ohms lower. If the skin were wet, the resistance would be much less; if the skin were oily it would be much more. Another point on which I would lay particular stress, is that the area of contact to get the same resistance in different persons would not be the same, and even with the person in different parts of the body the area of contact would have to be changed. To illustrate this I measured the resistance of six people, picked haphazard, from thumb to thumb, and although I was careful to obtain what I believe was the same amount of contact in each case, yet the resistance ranged all the way from 30,000 ohms to over 100,000 ohms, this being due most probably to different thickness and moistness of the skin. As regards the same person, I had my resistance measured from thumb to thumb, which gave 100,000 ohms, but from heel, where the boot rubs, to big toe, I got 200,000 ohms, although in each case I believe the same contact was made. The question of area of contact also plays an important part from another cause, as, if the area is small, the chance of burning is largely increased. (I shall discuss the question of burns by alternating and direct current later on, but a direct current burns much more severely, especially at the positive pole.) Burning not only numbs the nerves, and thus prevents feeling, but will also, I believe, be found to increase the resistance. Taking actual cases: "C" was working on a high-tension switchboard, and received a 2,000-volt alternating shock. The man was killed. I myself saw the body, and noticed that there was only a slight burn on the left hand, no other mark being found on the body. It was, therefore, impossible to say how the man really received the shock. "F" received a 2,000-volt alternating shock from hand to hand. Death occurred. The engineer on watch at the time told me that only slight burns were on each hand. In the case mentioned of a man killed on an arc circuit, only a slight redness was seen on his hand. Of course, this may not always be the case, as it is quite possible that the victim in his struggles to escape may reduce the contact and therefore cause severe burning after he had received sufficient current to kill him. In previous cases I have mentioned where the victim recovered, severe burning took place, and I shall mention more later on. I know I am laying myself open to severe criticism in bringing forward this theory, as the majority of electrical engineers, and also doctors, believe that severe burning means a severe shock.

(6) THE FATAL CRY; SPEECH AFTER RECEIVING A FATAL SHOCK.—It may be of interest to attempt to describe the cry, and as I have heard it three times, and have discussed this matter with others who have heard it, I think it can be accepted that this cry is best described as a rapid drawing in of the breath, followed by a half sigh, half shriek. In each of at least a dozen cases of

(3) PHYSIOLOGICAL CONDITION AS AFFECTING SUSCEPTIBILITY.—The first point which naturally occurs to one is, does a person in a heavy perspiration stand a better chance than one who is in a normal condition? To illustrate this I think I may quote the following case: "T" had been doing very heavy work, which made him perspire freely; to rest himself he sat down on a transformer, which was earthed, and in leaning back his head touched an inner terminal; as the outer was earthed he received a 2,000-volt shock. The man was wearing a thick flannel shirt, which was wet with perspiration. The result was that he received a most severe shock, a hole being burnt in his trousers, and the back of his head and buttocks were severely burnt. This man, I think, should have been killed, but he was not even insensible. Surely this seems to show that the sweat shunted the current, thus saving his life; although the burning probably protected him, as I will show later on. Again, would a man, when drunk, be less liable to be fatally injured? To illustrate this I give the following case: "F" was working in a transformer station as a laborer, and touched an inner terminal with one hand and an outer with the other, the potential difference being 2,000 volts. It was found out afterwards that the man was a heavy drinker, and was under the influence of drink when he received the shock, which did not even make him insensible. It is only fair,

(2) DISEASE AND HEALTH AS AFFECTING SUSCEPTIBILITY TO SHOCK.—I think I can prove that this question is of the utmost importance. Some years ago a number of friends were in the habit of measuring their resistance periodically, and it was found that one man was always the lowest, although they all varied. This man was also abnormally sensitive to an electric shock, as he could feel even so low a voltage as that from three Leclanché cells; it was afterwards found that he was suffering from kidney disease. This seems to indicate that the resistance of the body may be altered by disease, and it is most probable that the skin, by fulfilling the functions which by rights belong to the kidneys, had a lower resistance due to the impurities thus removed from the body. In a central station I was connected with it was the habit of the men to give an electric shock from a magneto machine to visitors, and although it was found that different people seemed to feel differently, yet one boy could stand more than anyone else. He was, however, unfortunately of weak intellect. Another case of which I heard was at a bazaar, where money was placed in a bowl of water charged from a Ruhmkorff coil. One woman took the money out every time, and had to be paid to go away, as she nearly made them bankrupt. She also was of weak intellect. No doubt their insensibility was due to the brain being affected. It appears, therefore, fair to say that a diseased person may be either more or less susceptible according to what disease one may be suffering from.

the body, health or disease, drunkenness or sobriety, whether the sufferer is asleep or awake, area and nature of contact, familiarity with shock, etc., all play most probably an important part in deciding what one feels, as I shall point out later on, I think my opinion will be accepted.

more or less severe shocks that have been reported to me the victim gave the cry, but in the case in which I personally saw the victim three witnesses were sure that he did not give the cry. With respect to the question as to whether a person can speak after he has received a fatal shock, I may say that I have always thought this impossible; but in the above case the victim was asked if he was hurt, and he said: "I am all right," and yet directly afterwards dropped down dead. Of course, one may ask, did he really die from an electric shock; but as a post-mortem was made, and the doctor satisfied himself that all the organs were healthy, I think there can be no doubt about it.

(7) ALTERNATING AND DIRECT-CURRENT SHOCKS.—As a direct current causes electrolytic action, and an alternating current does not, it seems that more must take place with direct current than with alternating current. It is also open to discussion whether, disregarding electrolytic action, the two act the same, as the alternating from its nature must have a spasmodic effect, whilst a direct current seems to paralyze at once. From my own experience of shocks, I am certain that the after effect of a direct current is worse than that of an alternating current. When looking at the matter, however, from an electrician's point of view, I can see a great difference, as there is no doubt that if contact is made with metal of such a shape that it cannot be gripped, and the current passes from hand to hand, the direct current seems to knock the victim down, whilst an alternating current seems to draw him closer and to tie his body as far as possible into a knot. On the other hand, if he can grip the metal, the direct current seems to hold him tighter than does the alternating current. Of course, I am only judging from what I have seen and felt myself.

Another influence which I believe plays an important part is the different action which the two currents have in breaking down a fault. No doubt this has some effect when a shock is received; most probably the direct current would reach its maximum before the alternating current, and, therefore, if a person is only in circuit for a short time, the direct current would have the greatest effect. On the other hand, more burning will take place with direct current than with alternating current, and as I have pointed out before, this is most probably a protection.

Although not strictly included in this paper, I should like to draw attention to the fact that an arc is more easily started with direct than with alternating current, and that when once started it is more easily maintained. It is possible for a man to be severely burnt on continuous current, and, therefore, all cases of exceptionally severe burning, if they occur on a low-tension supply, should be thoroughly investigated to prove whether death occurred from a shock due to burns or to an electric shock.

The conclusion I come to is that, if death occurs from an electric shock, both are equally dangerous; but if death occurs from burns the continuous current is more dangerous. To make myself thoroughly clear I should also like to say that, although burns are a protection against electric shocks, yet if carried to extremes they may themselves cause death due to shock.

It must be remembered that although the majority of deaths from electric shocks occur with alternating currents, yet the potential usually worked at with alternating is higher than that with direct current, and, therefore, the conditions required to cause death have to be more favorable with direct current than with alternating current. Taking the actual voltage required to cause death, independent of nature of supply, I should say: At below 600 volts the conditions must be abnormally favorable. At below 1,000 volts the higher the pressure the more easy it is to get the conditions necessary to cause death. The conclusion I come to is that there is nothing more dangerous in one system than in another. It is purely a question of voltage and of the conditions being favorable, and it must be remarked that as many conditions have to be favorable, it is really so difficult to get killed, even with a high voltage, that, practically, with our present knowledge, the chance of this occurring is no greater than in numerous other occupations where a person is likely to meet with an accident.

(8) IS THERE A CERTAIN METHOD OF ASCERTAINING WHETHER A MAN IS DEAD OR NOT?—In the "Electrical Review" rules, which I consider most excellent, and, indeed, invaluable, it is recommended to ascertain if the sphincter muscle is relaxed; but, as this is for obvious reasons objectionable, and also to a non-medical man most difficult to judge, I ask the doctors if they can tell us some better method. If they only knew what one feels when, after doing all one knows to restore a fellow worker to consciousness, the question arises, am I simply manipulating a dead body? I feel sure they would do all they could to tell us how to arrive at a definite conclusion.

(9) WHAT CAN DE DONE TO HELP THOSE WHO RECEIVE A SHOCK?—From medical evidence which I have read it appears as if the only thing which is unusual is that the blood appears different at post-mortem; but I believe this is open to discussion. I myself think, in view of facts I have previously stated, that the truth will probably be found to be that electricity acts like an anaesthetic, such as chloroform. In two cases of electric shock where death would have been expected the men recovered, in my opinion, from the head being lowered, thus flushing the brain with blood, which is exactly what doctors do when they want to revive a patient who has collapsed when under chloroform. The cases referred to are as follows: "B" received a 2,000-volt shock from hand to hand, but was not badly burned. He was insensible; we could not feel his heart beating and his breath did not cloud a mirror. His eyes were turned so that we could see only the whites of the eyes; his jaw was dropped, and thus seeing the man I could have been certain that he was dead. This man gave the "fatal cry"; an engine-driver who picked him up stood him on his head and thumped his chest, his reason being, as he put it, to start the blood flowing and, as the heart is a pump, to free the valves if they were stuck. After 45 minutes artificial respiration this man recovered. "T" received a 2,000-volt shock from hand to hand; he was standing on a short flight of steps, and fell head first off the steps about 4 ft. to the floor. As no one was present I cannot say if he gave the "fatal cry"; at any rate he came round without assistance in about 25 minutes. It is only fair to say that his hands were badly burnt. The question, therefore, I wish to ask the medical profession is whether we should adopt the same treatment as is used for collapse from chloroform, or whether there is any specific treatment that should be used in cases of severe electric shock.

ELECTRIC SHOCKS AT 500 VOLTS.

By Alexander P. Trotter.

A good deal of misapprehension exists as to the circumstances under which shocks at 500 volts may be felt, or the conditions which may lead to serious consequences. The electric pressure of 500 volts has become well established as the standard for electric traction, but apparatus designed for this pressure can be arranged to take another 100 or 150 volts without appreciable alteration; but considerations of commercial standardization seem to set the limit for working at about 600 volts. A pressure of 300 volts was used at first for electric traction, but when afterwards it was taken up and developed by Americans, they settled that a pressure of 500 volts was high enough for economy and not too high for safety.

Much popular misapprehension exists as to the danger from 500-volt circuits. The sensational press is for once in good company, the technical press and eminent practical electric traction engineers seem to have a horror of 500 volts. The chief object of this paper is to record a few experiments and to discuss the conditions under which shocks at 500 volts are devoid of danger.

The subject may be divided into three parts: (1) The physiological and electrical conditions; (2) the dangers connected with trolley wires; (3) the dangers of third rails of electric railways.

PHYSIOLOGICAL AND ELECTRICAL.—In dealing with the first part I need but barely allude to physiological matters. The sensation may be a prick, a pleasant tingle, a hot burning, or a convulsive shock. The sensation does not depend directly on the actual current, but on the current density. With 4 sq. ins. or 5 sq. ins. (30 sq. cm.) of contact between dry metal and bare skin (for example, grasping a trolley wire), a steady continuous current of 1 or 2 milliamperes is hardly perceptible. From 3 to 8 milliamperes are easily supportable, above 10 is painful, and above 35 almost unendurable. A larger current than 20 milliamperes is seldom used for medical applications. Every electrical engineer is familiar with the sharp, pricking shock given by a fine wire. In that case the current density is very high, but the current is so small that little else than the tactile nerve endings in the skin are stimulated. With larger currents and more surface muscular contractions are added to the tactile sensations, especially if the current is at all unsteady. The electrical phenomena of nerve and muscle have been studied by physiologists; they are rather complicated, and do not concern the general purpose of this paper. Alternating currents seem to be about four or five times more painful, but the sensation is of a different character. I have no knowledge of the relative danger of alternating and of continuous currents, and no further reference will be made to alternate currents in this paper.

It is difficult to make any exact determination of the relation between current density and sensation. More than about 14 milliamperes of steady continuous current at the finger tip, making a poor contact of about 1-6-sq. in. (1 sq. cm.), is unendurable, but 35 milliamperes from boot to boot, nearly the whole of the soles of the feet being in contact, is much less painful. Under prolonged shock the current increases, owing to a fall of resistance, but that does not concern accidental shocks.

Passing now to resistances, the resistance from finger tip to finger tip on dry metal and under 100 volts is about 20,000 ohms. It varies a little with the volts, decreasing at higher pressures. Two coins nipped in the terminals of an Evershed ohmmeter serve very well for electrodes. This finger-tip resistance is of considerable importance in connection with accidental light contacts at high pressures. The resistance is almost all at the skin. The thin skin on the inside of the wrist is much more sensitive than that of the palm of the hand. The difference between the resistance from finger to finger of one hand and between one finger of each hand is inappreciable. The resistance from hand to hand when grasping two pieces of dry trolley wire is about 5,000 ohms; different individuals vary a good deal, probably owing to the dryness of the skin; I have found it as high as 14,000. The resistance between the body and the earth or an iron rail through the sole of the foot, stocking and boot is of considerable importance in connection with electric railways. I find that the resistance from boot to boot, the boots being dry and without nails, varies from 45,000 to more than 500,000 ohms. The lowest of measurements on 25 different persons made with 500 volts gave 25,000 ohms. Boots worn into holes and wetted by walking on wet pavement gave only 13,000. The values for resistance for the human body given in medical works are of little use for the present purpose, for care is taken, as a rule, to facilitate the passage of the current. "Under conditions of medical practice, and using moistened electrodes, the resistance of the body, when the skin is well wetted with warm water, is about 2,000 or 3,000 ohms—that is to say, an E. M. F. of 12 volts (eight Leclanché cells) will pass a current of 4 to 6 milliamperes" ("Medical Electricity," Lewis Jones, p. 1904). Most of the measurements of resistance which I have given were made with 100 to 500 volts, and are calculated from the milliamperes which passed. Taking the information which I have already given about the effect produced by various currents, it follows that the mere touching of dry metal at 100 volts, finger to finger, gives hardly any sensation, but with a larger contact a shock is felt. At 200 volts a light touch gives an unpleasant prick, but the current through a firm contact is about 12 to 18 milliamperes, which most people can bear without considerable pain, especially if the contact be gradually made and broken. There is no after-effect; the sensation is very similar to that of heat.

To grasp, with bare hands, two pieces of metal at 500 volts would give a very painful shock, but a light and quick touch is no worse than the shock from a half-pint Leyden jar—an experience more familiar to school boys than to engineers. A 500-volt shock may be described as worse than touching a kettle of boiling water, not so bad as touching a red-hot poker, about the same as touching a soldering iron at working heat, or as when an inexperienced blacksmith's boy picks up a black-hot horse-shoe. These shocks are common incidents in the daily work of a careless linesman; nearly all those who are practically engaged in electric traction work receive more shocks than they like, but they agree that they might reduce the number by taking more care. This is an important measure of the severity of such shocks, and perhaps the only one which will be appreciated by those members of the public who do not care to try for themselves. In such brief shocks the muscular sensations probably mask the contact sensation, but a bad 500-volt shock burns the skin.

Cases of fatal accident from 500 volts are so rare that the conditions can only be guessed at. If the skin resistance be reduced by moisture, especially if salt or chemicals be present, and if the contact be large and prolonged, 100 volts may be fatal. While repairing an arc lamp in a steam-washing factory at Bradford, in 1899, a man is said to have been killed by a shock of 225 volts; a fatal accident occurred in Germany with about 300 volts, but a man may be choked by a crust of bread under exceptional conditions. The death of a man by blood poisoning arising from a burn caused by a short circuit on the Central London Railway in December, 1900, does not concern us; a death occurred on the Metropolitan Railway in Paris, when a platelayer fell and remained fallen on the third rail of 500 volts; but the case to which so much attention has been drawn, and which has caused such a scare, is the accident in Pembroke Place, Liverpool. Instead of the present system of well-earthed guard wires, an attempt was made to keep fallen telegraph wires from touching the trolley wire, and the attempt was unsuccessful. Nearly 50 wires fell in a tangle across the street, and lay on the trolley wire, which did not break. The passers-by in the street upon whom they fell escaped with a few shocks. It was dark and snowing, and a salted slush lay on the street. Two men walked blindly into the wires and were entangled, and struggling, became entangled the more. The current was not cut off for nearly half an hour. Here was a lamentable combination of seven circumstances: (1) The unusual conditions of weather, the snow freezing to the wires as it fell. (2) Failure of the wood strip (which is still extensively used on the Continent) to act as a guard. (3) The large number of wires, the long span (375 ft.), and the tangle in which they fell. (4) The salt slush of snow in the street. (5) The darkness and invisibility of the wires. (6) Failure of the pole telephone signal service. (7) The delay of 25 or 30 minutes before the current was cut off. If any one of these seven causes had been absent it is probable that the fatal results would not have occurred. It is practically impossible that such an accident can occur again in Liverpool, for the telephone wires which crossed the tramways have been either diverted, placed underground, or cabled, at a great expense to the corporation, and a considerable number of the postal telegraph wires have been satisfactorily altered. I am tempted to digress into the question of guard wiring, but this paper must be confined to shocks, and I hope that the discussion will be similarly restricted.

DANGERS CONNECTED WITH TROLLEY WIRES.—Neither the man in the street, nor a man on a car, runs any risk of taking 500 volts skin to metal. On several occasions during inspections of tramways, when a trolley wire has

been within reach from the top of a car, I have grasped it with both hands, and with more or less difficulty I have persuaded others to do the same. In each case the weather was fine, the car dry, and no shock, not even the least sensation was perceptible. To show that there was no trick I have grasped the hand-rail and flicked the trolley wire with a finger; the shock is trifling. It follows, therefore, that if a live trolley wire fall on a crowded car, although it may give alarming flashes when it touches a hand-rail, or tramway rail, the chances of a shock on a fairly dry day are nothing compared to the obvious mechanical injuries which might be occasioned. Trolley wires do fall, and trolley wires are very properly excluded from the leading cities of the world—London, Paris, Vienna, New York, Buda Pesth, etc., but as yet the damage done by the falls has not been electrical. A trolley wire is an obvious thing; it sometimes springs back in large coils, but it generally falls and lies still or hangs, and is regarded with a prudent solicitude which this paper is not intended to remove. But on a dry or frosty day any one with tolerably good boots may fearlessly touch the live end even if he stand on the rail. I would not publish this statement had I not tried the experiment on some dozen persons, the majority being women and children. My son, 7½ years old, stood on a rail and played with wires, there being 500 volts between rail and wires. The current was less than ¼ milliampere, and he felt nothing. His boots were new. A fallen telephone wire is not so obvious; it does not stop the traffic; it is apt to writhe and to coil round a person; should he fall on the rails the short circuit might severely burn him. With wet boots and ground the conditions are different. Standing on damp granite setts in rather damp boots, and grasping a trolley wire, I found the current was 15 milliamperes; the sensation was by no means unendurable; brief touches gave sharp pricks. Standing on a rail increased the current to 20 milliamperes. With old boots worn into holes, and after walking a couple of miles on wet pavement, standing on a rail and grasping a trolley wire gave 35 milliamperes. I took this for several seconds, and I should be sorry to take more. I broke contact cautiously by raising the boot on one edge. There was no after effect; the sensation was merely that of heat, as though the trolley wire were hot. Spilling half a bucket full of water on the ground increased the shock intolerably. I am inclined to attribute this to the better contact between boot and earth rather than to decreased resistance of the earth (in this case granite setts). Three others tried the experiments with me, and as far as we are able to compare experience I am satisfied that I am not relatively insusceptible to shocks.

Besides the fall of trolley wires, either on a car or in the streets, there are roundabout and unlikely ways in which shocks may be conveyed to unsuspecting persons—for example, a linesman on a ladder, and somehow making a good earth, holding a wire while its broken end or a careless sag touches a trolley wire; but the discussion of such accidents belongs to the subject of guard wires.

DANGERS CONNECTED WITH THIRD RAILS.—The first time I stepped on the live rail of a third-rail railway I clutched the engineer, lest my legs should give way under the shock; but I felt nothing. I went to where some water stood, ½-in. deep on a cement floor, and "marked time" for 2½ minutes. With caution I stepped on the live rail and then on one of the running rails, felt nothing, stooped down and touched the running rail while standing with both feet on the live rail. I felt a slight tingle, which my subsequent experiments lead me to think was produced by a current of about 6 milliamperes. To sit on the live rail without touching the running rails was easy, and I cautiously flicked the running rail, then touched it, and then laid my hands flat on it without the slightest sensation. In the light of the figures I have given, this is not at all surprising, and I have invited several others to try the experiment with the same negative result. Of course, the result depends on the dryness of the clothes. The resistance of dry cloth is very high. After walking in the wet for about an hour with sound but not thick shoes, I stepped on 500-volt rails and I felt nothing, but on touching with the finger I received a smart shock, perhaps 30 milliamperes. I have already stated that with old worn-out wet boots the resistance was only 13,000 ohms. This was found with only 400 volts. Standing on rails in my laboratory, the rails being connected to the outers of the Westminster Company, I could just support the current of about 30 milliamperes. The sensation was almost precisely like standing on hot steam pipes. It was easy to turn it on gradually by beginning and ending with the edge of the sole. The shock would, of course, be very alarming to any one who was not expecting it. There was no perceptible after effect. Ordinary nails in the heels of boots made no difference, but hob-nails give uncertain pricking stings which are rather painful, but under no circumstances need they be sustained.

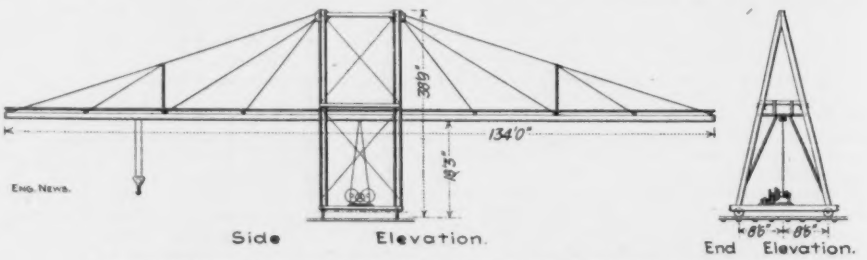
Until I tried these experiments I must confess that I did not enjoy the walks which I have sometimes taken in "tube" railways during inspections by the light of oil lanterns, but now, with dry boots, I take no care whatever. It is very desirable that the live rails of third-rail railways should be guarded by planks to prevent short circuits by tools, etc., and to make it less easy for a person falling on the rails to make contact with bare skin. While experience has shown that a person so falling may receive a serious and even fatal shock, this can only occur if he make contact with both a live rail and a running rail with bare skin or thoroughly wetted clothes, and if he lie there for a time. As to the length of this time we know nothing, but so long as the fall has not injured the person, so that he cannot rise, it is very improbable that the shock would be maintained. A platelayer in the open yard of the Waterloo and City Railway once accidentally sat on the third rail, and made the circuit through his feet on wet ground; he shouted, and was pulled off by his mates; the contraction of the muscles prevented him from rising. He could probably have rolled over, and so released himself. He was back at work again in a few minutes.

Numerous accidents to horses show conclusively that these animals are peculiarly susceptible to electric shocks. Electrical conditions under which a human being would receive an unpleasant shock of 10 to 15 milliamperes cause instant death to a horse, and it appears that horses are terrified under conditions where a human being would feel no shock. But it must not be concluded that a given current produces more effect on a horse than on a man. A horse makes excellent contact with its shoes, and these are well connected by nails to its body. It is probable that the resistance is very small, and the current very large; but even making this allowance, the horse appears to be more susceptible.

CONCLUSION.—The dangers of electric shocks at 500 volts have been much misunderstood, greatly exaggerated, and little investigated. The pressure of 500 volts has been deliberately chosen by electrical engineers because it is not dangerous under ordinary conditions. Dry wood and dry boots without large nails offer so great resistance to electric current, that it is perfectly safe to touch a trolley wire while standing on a dry tramcar, or even while standing on the ground, or on the rails. Wet weather makes a considerable difference, but boots must be very wet to allow enough current to pass to produce a severe shock. Dry clothing offers so great a resistance that no shock can be transmitted through it. The peculiar conditions under which shocks at 500 volts have caused death are shown to be very exceptional.

CANTILEVER CRANE FOR HANDLING STRUCTURAL IRON.

The firm of J. B. & J. M. Cornell has recently designed and built at its bridge and structural plant at Cold Spring, N. Y., a traveling cantilever crane for handling material in the beam yard. This has a capacity for hoisting 5 tons at the extreme end of the boom. The general design of this crane is shown in the accompanying cut. The tower consists of two steel A-frames 38 ft. 9 ins. high and about 15 ft. apart, standing upon a steel frame or deck mounted on four wheels. The wheelbase is 17 ft., and the gage of the track 15 ft. The crane is moved along the track by a 10-HP. electric motor geared to the wheels, the maximum speed being 100 ft. per minute.



5-TON CANTILEVER CRANE FOR HANDLING STRUCTURAL IRON.
J. B. & J. M. Cornell, Cold Spring, N. Y., Builders.

The boom is 134 ft. long over all, 18 ft. 3 ins. clear above the rails, and supported by guys from the top of the A-frames or towers. The boom consists of two steel channels set close together, with the flanges inwards, and the hoisting rope passing down through the slot between them. The wire hoisting rope is led over two drums on the deck of the tower, which are driven by a 10-HP. motor. The hoisting or lowering is effected by holding one drum stationary and operating the other. The traversing of the trolley along the boom is accomplished by paying out the rope from one drum and winding in upon the other, both drums always revolving at the same speed. The load remains suspended until one or other of the drums is stopped, when it is raised or lowered at will. The trolley travels the full length of the boom, and its load is balanced by a counterweight which always travels along the boom in the opposite direction to that of the trolley.

The lower part of the trolley is housed in to form the operator's cabin, and the motors are so arranged that one man controls all the operations of traversing the crane along its track, hoisting and lowering the load, and traversing the trolley along the boom.

A CANADIAN SURVEY PARTY is to be sent to the Albany River region, west of Hudson Bay. The party will be equipped for geological and topographical work, for timber, agricultural and other economic investigation. The region is unknown except to guides and Indians.

AN ITALIAN SHIP BUILT IN GENOA IN 1548, says a London news item, has been recently sold to be broken up at Tenerife, Canary Islands. This ship, the "Ar..." is very heavily built and resembled somewhat the ship of Columbus in model. She was very slow, and made her last trip in March, 1902.

A VERY LARGE WATER POWER SYSTEM is being planned in California. The flow of the Feather River, in the northern part of the state, is to be utilized, and a great storage reservoir, with a capacity of 240,000 acre-feet, is to be built for this purpose in the mountains of Plumas Co. From here the water will be conveyed through the mountains by a tunnel line to another large reservoir, which supplies the pressure lines directly. A head of 2,000 ft. down to the powerhouse can thus be obtained. The supply of water, together with the storage system, is such that in the driest series of years likely to be experienced a constant power of 300,000 HP. will be available, it is estimated. The project is promoted by the Western Power Co., Mr. J. M. Howells, Chief Engineer, and Mr. J. D. Schuyler, Consulting Engineer. Preliminary work is stated to be now in progress.

THE DISTRIBUTION OF AMERICAN EXPORTS of manufactures is reported upon by the U. S. Bureau of Statistics. This report shows that in 1901, 52% of the manufactures exported went to Europe, 23% to North America, 6.6% to South America, 8.2% to Asia, 7% to Oceanica, and a little less than 3% to Africa. Of the total exports to Europe—amounting in value to $215,000,000—the largest item was iron and steel manufactures, valued at $43,812,323; the next was copper, or $41,454,074; oil amounted to $40,735,548; leather to $21,211,083; agricultural implements, $10,494,530; chemicals, drugs and dyes, $6,741,068, etc. Iron and steel manufactures also constitute the largest item in the exports to North America, South America, Asia and Oceanica. In another table the bureau shows these exports for each year commencing with 1790, when the total value of exports of this class was valued at a little over $1,000,000 and formed 6% of the total. The value of these exports was only $17,500,000 in 1850; amounted to $122,577,652 in 1877; to $228,571,178 in 1896; and since 1900 the exportation of manufactures has constantly exceeded $400,000,000 per annum.

A STEEL STACK WAS LATELY ERECTED by a somewhat unusual method for the New York Central & Hudson River R. R., at West Albany, N. Y. This steel stack was built by the Franklin Boiler Works Co., of Troy, N. Y., and is 140 ft. high, and 10 ft. in diameter at the base, tapering to 5½ ft. at a point 12 ft. above the base. The approximate weight was 16 tons. The stack was riveted in 30 ft. lengths at the builders' shop, and thus conveyed to the site. To erect it, two gin-poles were set up, one on each side of the concrete foundation, and securely guyed; to the head of these gin-poles tackles were run through quadruple blocks, and through similar blocks at the base. The stack sections were laid between the poles and riveted up, and the completed stack was then lashed just above the center of weight; the tackle attached, and the stack was then hoisted by two gangs of men operating hand winches. As the stack rose it assumed nearly a vertical position, and the lower portion was then pushed in over the base-plate, bolts inserted, and the stack was in place. One whole day was consumed in lifting the stack, and part of another day in adjusting it in proper position on the base.